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Région des Maritimes

Framework for Assessing Lobster off the Coast of Eastern Cape Breton and the Eastern and South Shores of Nova Scotia (LFAs 27-33)

Cadre d'évaluation des stocks de homard situés au large de la côte dans l'est du Cap-Breton et le long des côtes est et sud de la Nouvelle-Écosse (ZPH 27-33)

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ABSTRACT

The elements of an **assessment framework** are presented for **Lobster Fishing Areas 27-33**. These LFAs cover the Atlantic coast of Nova Scotia from Cape Breton in the northeast (LFA 27) to the south shore of Nova Scotia (LFA 33) in the southwest. There are 1639 licenses of all types in LFAs 27-33. LFAs 27-32 are spring fisheries while LFA 33 is open from late November until the end of May. The biology of lobsters in these areas is reviewed. **A cluster analysis** of Statistical District (SD) landings from 1947-2009 is used to delineate **assessment units**. Three areas with landings that trended similarly were: (i) Northeastern Cape Breton (LFA 27), (ii) **Southeastern Cape Breton, Chedabucto Bay and the eastern shore (LFAs 29-32)** and (iii) the **South Shore (LFA 33)**.

Data inputs are described. They are primarily fishery-dependent and consist of landings and effort data from the fishery, port and at-sea samples of the commercial catch and data from standard traps maintained by **Fishermen and Scientist Research Society (FSRS)** study participants. **Landing** levels are a function of abundance and a wide range of other factors but are still thought to be indicative of general trends and patterns of abundance. **Catch rates (CPUE)** are also affected by factors other than abundance. Commercial CPUE for LFAs 27-33 comes from two sources: mandatory logs and voluntary logs. Return rates for mandatory logs have been in the 90-100% range in recent years, with useable data in the 85-100% range. The value of mandatory log data will increase with each additional year. Voluntary logs cover a longer period than the mandatory logs but the number of logs kept is small and decreasing is some assessment units. A comparison of data in LFAs 27 and 33 indicates the means from the voluntary logs are similar to the mandatory logs.

The CPUE from FSRS traps has the advantage that it originates from standard traps set over the whole Atlantic coast of Nova Scotia. A statistical model of CPUE from the FSRS trap data in LFA 27 provides an example of what could be applied in the other assessment units (LFAs 29-32 and LFA 33).The CPUE of lobsters was used to develop indicators of abundance for sublegal and legal size lobsters. The CPUE was modeled with a mixed effects model.

Two approaches for developing **indicators of reproduction** are illustrated. The first is from the CPUE of ovigerous females and an example using data from the port of Little River in LFA 27, is shown. The second approach is to develop an egg index by expanding the size composition from at-sea samples to the fishery from an abundance index and using the length-fecundity relationship to estimate the total number of eggs. The egg index is developed for LFA 31a and like landings, was substantially higher in more recent years compared to 2002-2003.

Indicators of **fishing pressure** based on lobster size structure have low value where recruitment has fluctuated as in several of the assessment units in LFAs 27-33. The **Continuous Change in Ratio (CCIR)** method for estimating **exploitation** was applied to a number of assessment subunits. This method is based on the ratio of the number of lobsters in the harvested (legal, "exploited") size classes to the number of lobsters in the unharvested

(sublegal, "reference") size class. Some assumptions of the method are explored. Confidence intervals indicate that with few exceptions, estimates of exploitation rate have not changed over the time period of available data (1999-2009). The CCIR estimates should be viewed as an index of exploitation.

The application of the **Reference Points (RPs)** to lobster fisheries in LFAs 27-33 is discussed in the context of Canada's precautionary approach and the current IFMP for LFAs 27-38. Options for RP development are provided. The candidate RPs in the most recent IFMP for LFAs 27-38 are based on landings from 1984-2004. Additional indicators of abundance are needed to develop RP. An abundance index for pre-recruits and commercial sizes based on FSRS catch rates is feasible for some assessment units. Recommendations for further development of RPs are provided.

RÉSUMÉ

Le présent document expose les éléments d'un **cadre d'évaluation** visant les **zones de pêche du homard (ZPH) 27 à 33.** Ces ZPH englobent la côte atlantique de la Nouvelle-Écosse, depuis le Cap-Breton, au nord-est (ZPH 27), jusqu'à la côte sud de la province (ZPH 33), au sud-ouest. On dénombre 1 639 permis de toutes catégories dans les ZPH 27-33. Dans les ZPH 27-32, la pêche a lieu au printemps, tandis que dans la ZPH 33, elle a lieu de la fin novembre à la fin mai. Le document traite aussi de la biologie du homard dans ces zones. Une **analyse typologique** des débarquements des districts statistiques de 1947 à 2009 est utilisée pour délimiter les **unités d'évaluation.** Trois secteurs présentaient des débarquements dont les tendances étaient similaires, soit i) le nord-est du Cap-Breton (ZPH 27), ii) **le sud-est du Cap-Breton, la baie Chedabucto et la côte est (ZPH29-32)** et iii) **la côte sud (ZPH 33)**.

On décrit ici les **données d'entrée**, qui sont principalement des données dépendantes de la pêche concernant les débarquements et l'effort de pêche, les résultats de l'échantillonnage, au port et en mer, des captures commerciales, et les captures de casiers standards utilisés par les participants à une étude de la **Fishermen and Scientist Research Society (FSRS).** Le niveau des **débarquements** est fonction de l'abondance et de nombreux autres facteurs, mais on continue de penser qu'il reflète les régimes et tendances de l'abondance. Les **taux de captures (CPUE)** sont aussi influencés par d'autres facteurs que l'abondance. Les CPUE de la pêche commerciale dans les ZPH 27-33 viennent de deux sources : les journaux de bord obligatoires et les journaux de bord facultatifs. Dans le cas des premiers, les taux de retour ont été de 90-100 % ces dernières années et les données utilisables de l'ordre de 85 à 100 %. La valeur de leurs données augmentera avec chaque année qui s'ajoutera à la série. Les journaux de bord facultatifs portent sur une plus longue période que ceux qui sont obligatoires, mais leur nombre reste faible et diminue même dans certaines unités d'évaluation. Il ressort d'une comparaison des données des ZPH 27 et 33 que les moyennes provenant des deux types de journaux de bord sont comparables.

Les CPUE obtenues dans les casiers de la FSRS ont l'avantage de provenir de casiers standards placées tout le long de la côte atlantique de la Nouvelle-Écosse. Un modèle statistique des CPUE découlant des données des casiers de la FSRS dans la ZPH 27 donne un exemple de ce qui pourrait être appliqué dans les autres unités d'évaluation (ZPH 29-32 et ZPH 33). Les CPUE concernant le homard ont servi à établir des indicateurs de l'abondance des homards de taille minimale réglementaire et de ceux qui n'avaient pas encore atteint cette taille. Les CPUE ont été modélisées d'après un modèle à effets mixtes.

Deux façons d'établir des **indicateurs de la reproduction** sont illustrées. La première est fondée sur les CPUE des femelles ovifères et on en présente un exemple faisant appel aux données du port de Little River, dans la ZPH 27. La seconde consiste à établir un indice de ponte en extrapolant aux données de la pêche la composition des captures selon la taille observée dans l'échantillonnage en mer d'après un indice de l'abondance et en utilisant la relation longueur-fécondité pour estimer le nombre total d'œufs. L'indice de ponte a été calculé pour la ZPH 31a et, tout comme les débarquements, il était notablement plus élevé ces dernières années qu'en 2002-2003.

Les indicateurs de la **pression de pêche** fondés sur la structure de tailles du homard ont peu de valeur là où le recrutement a fluctué, comme dans plusieurs des unités d'évaluation des ZPH 27 à 33. La méthode **du changement de proportions en continu** (Continuous Change in Ratio - CCIR) servant à estimer l'**exploitation** a été appliquée à diverses sous-unités d'évaluation. Cette méthode est fondée sur la proportion entre le nombre de homards se situant dans les catégories de tailles capturées (tailles réglementaires ou « exploitées ») et le nombre

de homards se situant dans la catégorie des tailles non capturées (tailles non réglementaires ou « de référence »). Certaines des hypothèses associées à la méthode sont explorées. Les intervalles de confiance révèlent que les estimations du taux d'exploitation n'ont pas changé sur toute la période pour laquelle on dispose de données (1999-2009), à quelques exceptions près. Les estimations obtenues à l'aide de la méthode CCIR devraient être considérées comme un indice de l'exploitation.

Le document traite de l'application de **points de référence (PR)** aux pêches de homard dans les ZPH 27-33 dans le contexte de l'approche de précaution adoptée par le Canada et de l'actuel PGIP visant les ZPH 27-38. Des options sont présentées pour l'établissement de PR. Les PR proposés dans le PGIP le plus récent applicable aux ZPH 27-38 sont fondés sur les débarquements de la période 1984-2004. D'autres indicateurs de l'abondance sont nécessaires pour fixer des PR. Il est possible d'établir un indice de l'abondance des prérecrues et des homards de taille commerciale fondé sur les taux de captures dans les casiers de la FSRS pour ce qui concerne certaines unités d'évaluation. Des recommandations pour l'établissement de PR sont présentées.

1. INTRODUCTION

1.1 CONTEXT AND TERMS OF REFERENCE FOR FRAMEWORK

Lobsters (*Homarus americanus*) are found in coastal waters from southern Labrador to Maryland, with the major fisheries concentrated around the Gulf of St. Lawrence and the Gulf of Maine. Though lobster are most common in coastal waters, they are also found in deeper, warm water areas of the Gulf of Maine and along the outer edge of the continental shelf from Sable Island to off North Carolina.

The status of the lobster resources in Lobster Fishing Areas (LFAs) 27-33 was last assessed in 2004. Fisheries and Aquaculture management has requested updated information on the status of the LFA 27-33 lobster stocks, and a new assessment framework is required to establish the scientific basis for the provision of management advice in 2011.

Currently there are no direct indicators of abundance available for the lobster fishery and reference points in the draft IFMP have been tentatively framed in terms of landings. It is recognized that landings are not a very sensitive indicator of biomass given the influence of changes in effort, efficiency and catchability and there is a need to develop biologically-based reference points. The potential for alternate proxies for biomass will be evaluated.

Objectives

- Identify groups of LFAs for stock assessment.
- Identify links between life-history (size-at-maturity, recruitment) and lobster management (update and reporting on information and assumptions used).
- Identify strengths and weaknesses of fishery data inputs for providing indicators of abundance, size structure, recruitment, effort, spatial distribution of catch.
  - Port and at sea sampling protocols
  - Observer sampling (including bycatch sampling associated with SARA)
  - Logbooks
  - Fishermen and Scientists Research Society (FSRS) information
- Select indicators of abundance, with a focus on a proposed catch rate model.
- Select indicators of recruitment and reproduction (spawners).
- Select indicators of fishing pressure.
- For the selected indicators develop candidate reference points that would form the bases for decisions by Fisheries Management.
- Development of an assessment schedule, including guidelines for the monitoring of the indicators and other events that would trigger an earlier than scheduled assessment.

The above objectives are addressed in the current Working Paper (WP) and separate WPs on lobster size at sexual maturity.

1.2. ASSESSMENT HISTORY

Lobster assessments are conducted periodically through the Regional Assessment Process (RAP) coordinated by the Canadian Science Advisory Secretariat (CSAS). The target frequency for full assessments for LFAs in the Maritimes Regions is every 5 years. LFAs 27-33 were last assessed in 2004. LFAs 34, 35-38 and 41 are assessed on a different time frame because of different data sources and the relative size of the fisheries involved.

***Table 1** – List of lobster assessments in the Maritimes Region 1996-2009. (http://www.dfo-mpo.gc.ca/csas*

LFA	Assessment Year	Stock Advisory Report (SAR) / Stock Status Report (SSR)	CSAS Research Document
27-30	1996	1996/116	1996/141
	1998	1998/C3-59	1998/124
	2004	2004/032	2004/021
31-32	1996	1996/117	1997/001
	1998	1998/C3-60	
	2004	2004/033	2004/037, 2004/038
33	1996	1996/117	1997/001
	1998	1998/C3-60	
	2004	2004/038	2004/071
34	1998	1998/C3-62	1999/032
	2001	2001/C3-62	2001/156
	2006	2006/024	2006/010
35-38	1998	1998/C3-61	1999/031
	2001	2001/C3-61	2001/093, 2001/094
	2007	2007/037	2007/041
41	2000	2000/C3-14	2001/131
	2009	2009/033	2009/023

Since 2005, Science has also provided advice to Fisheries Management in the form of Science Responses or Expert Opinions. For lobster, these are listed as follows in Table 2. In addition to the above documents, there have been several research documents on special topics, and these are listed in Table 3.

***Table 2** – List of lobster related science response and expert opinions in the Maritimes Region 2005-2008. (http://www.dfo-mpo.gc.ca/csas*

Title	CSAS Science Response
Expert Opinion on LFA 33 Lobster Season Extension Framework	2005/01
Scientific advice on causes of lobster damage in LFA 33 and LFA 34.	2008/004
Biological Basis for the Protection of Large Lobsters in Lobster Fishing Areas 33 to 38	2008/017

***Table 3** – List of special topics papers associated with lobster in the Maritimes Region 1997-2005. (http://www.dfo-mpo.gc.ca/csas*

Title	CSAS Research Document
Temperature, catch rate and catchability during the spring lobster fishery off eastern Cape Breton Island.	1997/119
Spatial correlations in catch rates, annual landings, and lobster sizes among port clusters in the LFA 33 lobster fishery	2001/019
Lobster Fishing Effort on the Outer Coast of Nova Scotia 1983 versus 1998	2002/022
Temperature Conditions in Lobster Fishing Areas 27-33 on the Scotian Shelf: 1999-2003.	2004/046
Temperature Conditions in Lobster Fishing Area 34 on the Scotian Shelf and Eastern Gulf of Maine: 1999-2004.	2005/027

1.3 OVERVIEW OF THE FISHERY IN LFAs 27-33

LFA 27-33 stretches from the northern tip of Cape Breton Island to Barrington Bay (Shelburne County) in the south (Fig. 1) and though the LFAs extend out to 92 km (50 nautical miles) fishing generally occurs within 15 km from shore.

LFA 27-33 landed approximately 9500 mt of lobsters in 2008 with a landed value of over $106 million. LFA 27-33 accounted for 30% of the Maritime Regions lobster landings by weight, 17% of Canadian landings and 9% of the world landings of *Homarus americanus*.

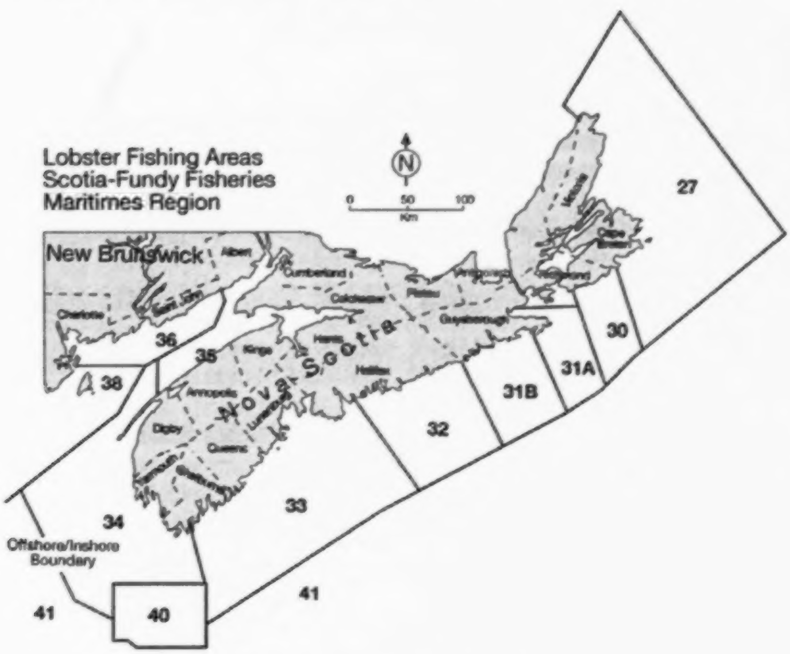


***Figure. 1** – Lobster fishing areas (LFAs) in the Maritimes Region.*

The fishery is managed by input controls including seasons, trap limits, minimum size carapace length (CL), and prohibition on landing berried or v-notched female lobsters (Table 4).

There are 1,639 licences of all types in LFAs 27-33 (Table 5) with almost all coastal communities involved in the inshore lobster fishery. LFA 27-32 are spring/ early summer fisheries while LFA 33 is a fall/winter/spring fishery (Table 5). The fishery is prosecuted by vessels less than 13.7 m (45') Length Overall (LOA). In LFAs 33 and 34 the maximum vessel length is restricted to 13.7 m with an authorized maximum stern extension of 1.5 m (5'). All other Maritimes Region LFAs can utilize vessels up to 19.8 m (65') LOA, however, few if any, exceed 13.7 m.

***Table 4** – Current Management Measures. Taken from April 2010 draft of Inshore Lobster IFMP [with correction for LFA 27 season].*

LFA	Season	Trap Limit[1]	Legal Size (mm)	Other Measures
27	May 15 - July 15	275	81	
28	April 30 - June 30	250	84	Release V-notch
29	April 30 - June 30	250	84	V-notching[2]
30	May 20 - July 20	250	82.5	Max. CL-135mm;V-notching
31A	April 29 - June 30	250	82.5	Closed window,114-124 mm
31B	April 19 - June 20	250	82.5	V-notching and release of 100lb of mature females/ licence
32	April 19 - June 20	250	82.5	V-notching and release of 100lb of mature females/ licence
33	Last Mon. Nov - May 31	250	82.5	Release V-notch

1 Trap limit is for "A" licence holder. Part-time or "B" licences are allowed 30% and Partnerships 150% the limit of a single full-time licence.
2 V-notching means there is an active program to V-notch berried lobsters. There is a possession restriction of V-notched lobsters except in LFA 27 and LFA 31A.

***Table 5** – Number of Lobster Licenses by LFA and Category, Dec 31, 2009. Taken from April 2010 draft of Inshore Lobster IFMP.*

LFA	Licence Category					
	A[1]	B	P[2]	CC[3]	CC-P[4]	Total
27	464	19	26	11	4	524
28	8	1		7		16
29	52	9		6		67
30	20					20
31A	67[5]	4	2			73
31B	70	1				71
32	143	8	4	6		161
33	532	50	111	12	2	707
34	941		14	30		985
35	75	3	2	15		95
36	144	1	18	8	6	177
38	81	1	38	8	8	136
Total	2557	97	215	103	20	2992

1. Category A vessel based limited licences
2. Partnership A vessel based limited licences
3. Category A Commercial Communal vessel based limited licences
4. Partnership A Commercial Communal vessel based limited licences
5. Includes one temporary licence in the name of Guysborough County Inshore Fisherman's Association that is no longer issued.

Source: DFO Licensing Summary Report as of Dec 31, 2009 (LS4041A)

1.4 LOBSTER BIOLOGY

1.4.1 Early Life History

Lobsters have a planktonic larval period that takes a few weeks to a month or more depending on temperature, before settlement. The larvae are chiefly in the surface waters, although they undergo a daily vertical migration. There are 3 larval stages followed by a postlarval stage that is planktonic for a few days to weeks until it begins diving to the bottom to search for shelter

providing habitat. Growth studies in the laboratory indicate stages 1-3 take 35 d at 12 °C and 22 d at 15 °C (MacKenzie 1988). Field estimates of larval duration suggest development in the plankton can be substantially faster (Annis et al. 2007).

Little is known about the larval distribution along the South and Eastern Shores of Nova Scotia and Cape Breton as detailed circulation models are lacking. Along this coast, lobsters are more restricted to the coastal bays and though larval exchange may occur along the coast, a portion of the larvae may be retained in the local areas. One study however suggests that there is potential for rapid larval loss from bays due to flushing (Dibacco and Pringle 1992).

Halfway through the postlarval stage, lobsters leave the surface waters, and after some trial-and-error settle preferentially on substrates that provide shelter, in particular hard bottom with cobbles. There have been some observations of settlers in eel grass and in areas with hard clay or mud sediment that is conducive to burrowing. Larval stages and postlarval lobsters feed on a variety of plankton species but predominantly on cladocerans, copepods, and crab larvae (Harding 1992, Lavalli and Lawton 1996). Once the postlarvae find suitable shelter on the bottom they tend to remain in or near the shelter to avoid predation. As postlarvae grow they increase the time spent outside the shelter (Lavalli and Lawton 1996).

Over the last 4 years DFO has piloted a tool for sampling lobster post-larvae and small juvenile lobsters. The goal of this work is to develop an index of the number of settlers in different parts of coastal Nova Scotia (Tremblay, 2010). This work is ongoing and settlement density may form the basis of a future reference point.

1.4.2 Age and Growth

Lobsters cannot be aged directly due to the lack of hard parts that are retained through the moult. In the Maritimes Region, lobsters are thought to take approximately 8-10 years on average to reach the legal size of 82.5 mm carapace length (CL) (81 mm in LFA 27 as of 2009). This is based on growth studies in adjacent regions (Gendron and Sainte-Marie 2006) and tagging studies of pre-recruit lobsters in the region which indicate annual moults by most individuals (Miller et al. 1989, Tremblay and Eagles 1997). Lobster age at size may be quite variable based on results from analyses of the "age pigment", lipofuscin. Studies of lipofuscin in *Homarus gammarus* indicate that lobsters 85 mm CL may comprise up to 7 year-classes (Sheehy et al. 1999). Lipofuscin accumulation is however affected by ambient temperature and challenges remain for applying the technique to wild-caught lobsters and other decapods such as blue crab because of the potentially variable temperature history of individuals (Wahle and Fogarty 2006, Puckett et al. 2008).

At legal size lobsters weigh approximately 0.45 kg (one pound) and generally moult once a year. Larger lobsters moult less often, with a 1.4 kg (three pound) lobster moulting every two to three years. The largest recorded lobster was 20.14 kg (44.4lb) (Guinness Book of Records). The maximum age of lobsters is unknown but based on growth information and long term holding studies it believed to be in the range of 50 years.

Growth increments are dependent upon size, sex and maturity with the mean growth increment for males and immature females between 12-16% while mature females exhibit a declining % increase with size as more energy is invested in egg production.

Tagging studies to assess growth and movement were conducted in the 1990s in LFA 27 (specifically the port of Little River Cape Breton and some adjacent ports) (Tremblay and Eagles 1997, Tremblay et al. 1998). The growth increments recorded for lobsters off Little River are in

line with other studies of *Homarus americanus* in the southern Gulf of St. Lawrence and along coastal Nova Scotia (Miller et al. 1989, Comeau and Savoie 2001). Estimated growth increments for an 80 mm CL male ranged from 10.3 mm (13%) to 12.9 mm (16%); for females, estimated increments for an 80 mm CL animal ranged from 9.7 mm (12%), to 11.4 mm (14%).

1.4.3 Reproductive Potential

The usual reproductive pattern is for the mature female to mate in late summer while in a soft shell condition immediately after moulting. The male transfers a spermatophore into the seminal receptacle at the base of the female's tail. Over the next year the eggs develop in the female's ovaries and following summer the eggs are extruded, fertilized and then attached to the underside of the tail. The eggs are then carried for 10-12 months and hatch the following July or August. Lobsters mature at varying sizes depending upon local water temperatures (Aiken and Waddy 1980, Campbell and Robinson 1983, Aiken and Waddy 1986, Waddy and Aiken 1991, Comeau and Savoie 2002a, Comeau 2003, Waddy and Aiken 2005), maturing at smaller sizes in regions with warm summer temperatures (Gulf of St. Lawrence, southern New England) and at larger sizes in regions with cooler summer temperatures (Bay of Fundy, north-eastern Maine).

Maturity estimates for LFAs 27-33 are presently being re-evaluated and are will be presented in companion research documents. The best estimates available at this time for the size at which 50% of the females are mature are given in Figure 2 below (the vertical bars represent the potential range) (Campbell and Robinson 1983, Miller and Watson 1991, Reeves et al unpublished), and are what was provided to Fisheries Management for the Atlantic Lobster Sustainability Measures program (ALSM).

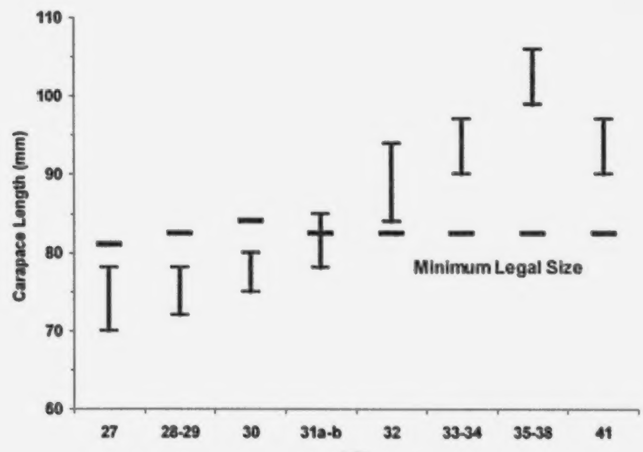


Figure 2 – Female lobster size at 50% sexual maturity ("SOM50") with "best estimates" of range in size. This display is as of 2009; values for LFAs 27-33 are all being evaluated. See separate working papers on size at maturity.

At maturity, lobsters produce eggs every second year. Based on laboratory studies using ambient inshore Bay of Fundy water temperatures, female lobsters appear able to spawn twice without an intervening moult (consecutive spawning) at some size greater than 120 mm CL (Waddy and Aiken 1986, 1990) though this size may vary in nature (Campbell 1983, Comeau and Savoie 2001, 2002a). Consecutive spawning occurs in two forms: successive-year (spawning in two successive summers, a moult in the first and fourth years) and alternate-year

(spawning in alternate summers). In both types, females often are able to fertilize the two successive broods with the sperm from a single insemination (multiple fertilizations). Intermoult mating has also been observed in laboratory conditions (Waddy and Aiken 1990).

Consecutive spawning and multiple fertilizations enable large lobsters to spawn more frequently over the long term than their smaller counterparts. This combined with the logarithmic relationship between body size and numbers of eggs produced means that very large lobsters have a much greater relative fecundity (Campbell and Robinson 1983, Estrella and Cadrin 1995). Protection of large females that are multiple breeders results in increased egg production and a greater diversity of breeders that should lead to more successful egg production under a variety of environmental conditions (DFO, 2009).

1.4.4 Distribution

The North American lobster (*Homarus americanus*) is widely distributed in coastal waters from the southern tip of Labrador to Maryland, with the major fisheries concentrated in the Gulf of St. Lawrence and the Gulf of Maine (Figure 3). Lobsters are also found in deeper waters (down to 750 m) in the Gulf of Maine and along the outer edge of the continental shelf from Sable Island to off North Carolina. This deep water distribution is due to the presence of the warm slope water that keeps the slope and deep basins in the Gulf of Maine warm year-round. This warm deep water is not found on the eastern Scotian Shelf, in the Gulf of St Lawrence or off Newfoundland.

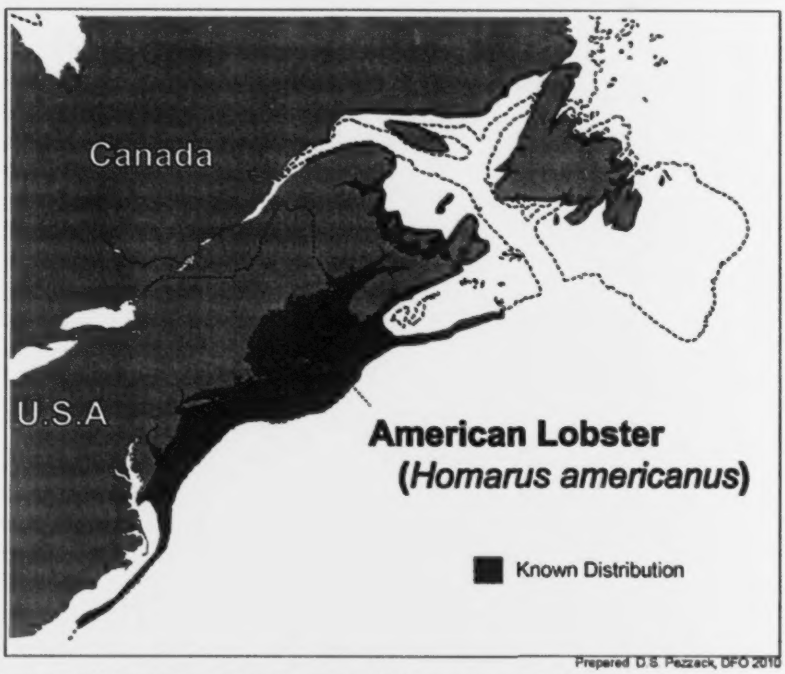


***Figure 3** – Lobster distribution based on known fishing areas and DFO and NMFS bottom trawl surveys.*

Lobsters are a temperate species that requires sufficiently warm summer temperatures to grow and produce and hatch their eggs. Juvenile and adult lobsters can exist in waters from less than 0°C to approximately 25°C. Larval lobsters occur in surface waters between 6 and 25°C, though a minimum temperature of approximately 10-12°C appears to be required for successful

development to the settlement phase (stage IV). Larval development is temperature dependent and takes just 10 days at 22-24°C but over 2 months at 10°C.

At the northern limit of their range (Northern Newfoundland) summer temperatures remain too cold for ovary and egg development while at the southern limit of their range (Maryland coastal and off Cape Hatteras along the slope edge) winter temperatures remain too warm and the moulting and reproductive cycles are not synchronized.

Juvenile and adult lobsters can tolerate a wide range of salinities from 15 to 32 ppt (parts per thousand) but can be affected by low salinities associated with spring melts or heavy runoffs in shallow estuaries. Larval lobsters are sensitive to salinities below 20 ppt, and alter their depth by actively swimming to avoid low-salinity surface waters. Moulting lobsters are less resistant to low salinities than are hard-shelled lobsters due to the osmotic permeability of their skeletons.

Lobsters are found on many different bottom types from mud and sand to cobble and boulders. Young lobsters require shelter to avoid predators so are more restricted in their habitat than larger lobsters. Newly settled and juvenile lobsters are most common in complex habitats such as cobble or gravel bottoms, or eel grass. They are also capable of burrowing so can also be found in areas with compact clays or peat reefs which can be burrowed into. As they grow and become less susceptible to predators they are found in more varied bottoms including open mud and sand bottoms.

1.4.5 Migrations and Depth Preferences

Adult lobsters make seasonal migrations to shallower waters in summer and deeper waters in winter (Cooper and Uzmann 1971, Cooper et al. 1975, Fogarty et al. 1980, Campbell et al. 1984, Ennis 1984, Campbell and Stasko 1986, Pezzack and Duggan 1986, Estrella and Morrissey 1997, Tremblay et al. 1998, Comeau and Savoie 2002b, Bowlby et al. 2007, Cowan et al. 2007). Mature lobsters on average move significantly greater distances then immature animals (Campbell 1986, Campbell and Stasko 1986). Over most of their range, these movements vary from a few kilometres to 20 km. However, in the Gulf of Maine and on the outer continental shelf lobsters undertake long distance migrations of tens to hundreds of kilometres. Tagging studies have shown that at least some of these lobsters return to the same area each year (Campbell 1986, Pezzack and Duggan 1986).

In general lobsters appear to move less in eastern Nova Scotia than in the Gulf of Maine. On the outer coast of Nova Scotia, lobsters with Sphyrion tags were released at one location in both 1978 and 1979 and at seven locations in 1982. Among 698 lobsters recaptured in this study after 1-6 years at liberty, only three were recovered > 12 km from their release point. Other published reports representing many areas in Atlantic Canada and Maine that recruit sized lobsters are usually recovered within < 12 km of release sites (Miller et al. 1989). Off north-eastern Cape Breton, a total of 3684 lobsters were tagged between 1993 and 1995 (Tremblay et al. 1998). These ranged in size from 52-130 mm carapace length (CL) with an average size of 78 mm CL. Greater than 80% of lobsters were recaptured less than 6 km from their release site after 1-2 seasons at large. There was no detectable effect of size or gender on distance moved. Multiple recaptures of single lobsters showed a variety of movement patterns.

Recent tagging done by the ESFPA as part of their lobster v-notch program in LFA 31b-32 showed the same general pattern of most lobsters remaining in the general area of the tag release, however the data also shows a small number of long distance movements to the Gulf of Maine and Georges Bank. Some caution is needed in interpretation of these results as the exact origin of the lobsters tagged was not always known and homing-like behaviour has been

noted in lobster tagging studies that involved the relocation of lobsters (Saila and Flowers 1968, Duggan and Pezzack 1988, Duggan 1991).

Migrations may be undertaken to optimize the temperature to which lobsters and their eggs are exposed, to avoid shallow water during stormier winter periods and to migrate to areas optimal for hatching eggs and either retention or export of larvae. The triggers for these migrations are not well understood.

Quantitative estimates of exchange rates between areas would improve our understanding of stock relationships but such estimates are a challenge. The mark-recapture approach used in historical studies does not permit discrimination between residences and return migrations after lengthy periods at large, except where intervening recaptures of the same individual lobster are involved. The origin of the animals that are tagged in any one location is unknown. Determining the proportion of animals in the population that make long distance movements is confounded by regional differences in the reporting rate of recaptures and the fact that where local fisheries are intense; there is a low probability that legal-sized animals survive to move long distances. The closed season in inshore fisheries also poses a problem in that summer movements would not have been detected in these earlier studies.

1.4.6 Natural Mortality

Natural mortality (M) has been estimated for some nearshore populations and is generally assumed to be between 10-15% for all fully recruited legal sized lobsters and, in most models (Fogarty and Idoine 1988, Gendron and Gagnon 2001, Idoine et al. 2001, Gendron 2005), is assumed to be the same over time and for all size groups. However, in reality, this could vary greatly depending upon habitat, predator abundance, and lobster size.

A constant M is usually chosen using life history criteria such as longevity, growth rate, and age at maturity. American lobsters have a relatively long life span and slow reproduction and are thus classified by biologists as "k-selected" with low natural mortality after the larval stage. The uncertainty of the natural mortality is in part due to the lack of an accurate ageing method.

1.4.7 Lobster Stock Structure

Studies of American lobster stock structure report some differences among widely separate areas, but mixing at some life history stage appears to be the rule.

Some studies of lobster morphometrics have indicated discrimination of stocks is possible on the basis of morphometrics (Harding et al. 1993, Cadrin 1995). Harding et al. (1993) reported that morphological characteristics of the first larval stage separated the southern Gulf of St. Lawrence (and its outflow around Cape Breton Island) from the large area represented by the Atlantic inshore region of Nova Scotia and the offshore banks bordering the Gulf of Maine. In a study of inshore and offshore lobsters in the Gulf of Maine, Cadrin (1995) demonstrated that males could be distinguished on the basis of relative claw size.

Most studies of lobster stock structure using genetic tools have found limited genetic differentiation (Tracey et al. 1975, Harding et al. 1997, Crivello et al. 2005a, Crivello et al. 2005b). An early study of eight populations of lobsters found low levels of genetic variability and that interpopulation differences were small (Tracey et al. 1975). Differentiation between populations supported the suggestion that *H. americanus* is subdivided into a number of more or less geographically isolated inshore and offshore populations, but that these local populations are nonetheless genetically similar. Some non-adjacent areas have been found to be more

genetically distant than adjacent areas (e.g. the southern Gulf of St. Lawrence compared with the Gulf of Maine - Harding et al. 1997) but overall the results suggest extensive mixing among areas in the northwest Atlantic.

Recently, Kenchington et al. (2009) used microsatellite DNA markers to examine the large-scale population structure of lobsters throughout eastern North America. This paper documents a North/South separation with a relatively homogenous population to the north (centered in the Gulf of St. Lawrence and extending down the coast of Nova Scotia to Shelburne County west of Halifax) and more heterogeneous populations in the south (centered in the Gulf of Maine and the Mid-Atlantic Bight region). At smaller geographical scales, the analyses identified areas of low gene flow between some areas, which are likely to be shaped by ocean currents and lobster migration patterns. These areas of restricted gene flow were particularly common in the Gulf of Maine and areas south of it.

Genetic studies may not identify areas of lobster production that respond in a similar manner to changes in the ecosystem, to fishing pressure and to conservation measures. FRCC (1995) advocated the move towards "Lobster Production Areas" within which conservation strategies could be applied. These LPAs should have similar biological characteristics and environmental characteristics. Based on bottom temperature, substrate, currents and lobster size at maturity they recognized 7 LPAs in the Atlantic zone. Within coastal Nova Scotia they recognized 3: an LPA that included Chedabucto Bay, eastern Cape Breton and the southern Gulf of St. Lawrence, and LPA from Canso to Lobster Bay in LFA 34, and one for the Canadian Gulf of Maine and Bay of Fundy. These LPAs were never formally adopted and the one including Cape Breton appears particularly coarse.

Trends in lobster landings may be the best available tool to identify stock assessment units. In the 1980s and early 1990s there were several papers on lobster landings in coastal NS and the Maritimes (Campbell and Mohn 1983, Harding et al. 1983, Pezzack 1992, Hudon 1994). The most recent of these uses landings data only up until 1991. These analyses are predicated on the assumption that landings bear some relationship with abundance. Three stock areas can be recognized based on the earlier papers: north-eastern Cape Breton (LFA 27); southeast CB and eastern shore (LFAs 29-32) and south shore (LFA 33). LFA 28 (Bras d'Or Lake) was not part of these analyses as historically landings were not kept separate for this LFA. Stock assessment units are re-revaluated based on landings trends from 1947-2009 in Section 2.

1.5 MANAGEMENT

Inshore lobster is one of the oldest managed fisheries in Canada with the first regulations in 1873 and since the late 1800s numerous regulations have been applied to the lobster fishery. Most regulations initially were based on market requirements and considerations and not on biological concerns. The first regulatory measures were introduced in 1873 putting restrictions on soft shell lobsters and egg bearing females. Seasons were introduced in the Bay of Fundy area as early as 1879 with additional size restrictions coming into play in 1899. However, throughout the late 1800's and up until the mid-1900's enforcement of these initial regulations was very sporadic and inconsistent.

In 1967 a limited entry licensing policy was introduced in portions of Prince Edward Island and New Brunswick and the remainder of the Maritimes in 1968. Prior to that, anyone could receive a lobster licence. Along with limiting the number of licences, the department introduced trap limits and also more formally defined boundaries for most of the modern day Lobster Fishing Areas as they currently exist.

In 1976, three categories of licences were created, i.e.; Category A licences for those fully dependent on the fishery, Category B for those not fully dependent but with a historical attachment to the lobster fishery since 1968 and Category C licence that had little or no dependency and which expired in two years. Category B licences were eligible to fish one third of the trap limit for a Category A licence. Category B licences have never been transferable and expire upon the death of the licence holder.

In 1978 to 1981, a lobster licence buy-back program was implemented to further reduce the number of participants, many of whom were not dependent on the fishery. Approximately 1400 licences were retired in Nova Scotia.

In the mid to late 1980's, requirements were introduced for escape vents and biodegradable (ghost fishing) panels to be installed in lobster traps. Following the first report of the Fisheries Research Conservation Council (FRCC 1995), a four year plan was introduced that resulted in some minor increases in minimum legal carapace size, a maximum size on females in one LFA, a slot or window size restriction in one other LFA and adoption of a voluntary v-notching program by harvesters in almost all LFA's. In July 2007, the FRCC published their second report, Sustainability Framework for Atlantic Lobster in which they concluded that high levels of exploitation and effective fishing effort remain as a high risk to the long term sustainability of the inshore lobster fishery.

The inshore lobster fishery in the Maritimes Region is composed solely of commercial and Food Social and Ceremonial (FSC) components. There is no authorized recreational harvesting of lobster in this region.

Recent Management Issues

A major conservation management program was initiated in Atlantic Canada in light of the October 1995 review of the Atlantic lobster fishery by the Fisheries Resource Conservation Council (FRCC 1995). In their report, the FRCC concluded that under the current management regimes, lobster fishermen generally were "taking too much, and leaving too little". Based on the scientific data available to the Council, they concluded that Atlantic lobster fisheries had high exploitation rate and harvested primarily immature animals, resulting in very low levels of eggs-per-recruit. While they accepted that lobster stocks have traditionally been quite resilient, they concluded that the risk of recruitment failure was unacceptably high and suggested a need to increase egg production.

The second FRCC report in 2007 (FRCC 2007) reiterated the concerns from the first report and made recommendations on methods for improving the sustainability of the fishery.

In LFAs 27-33 there have been substantial management changes since 1998 (Table 6). LFA 27 has seen the largest change, with an increase in carapace length of a full 11 mm since 1998. The effects of changes prior to 2004 were evaluated in earlier Research documents.

Table 6 – Major changes in management regime for LFAs 27-33 from 1998 to 2007.

LFA	Carapace Length			Other Management Measures
	Old Size (mm)	New Size (mm)	Time Period Over Which Change Occurred	
27	70 76	76 81	(1999-2002) (2007-2009)	
28	81	84	1999	Trap limit reduced from 275-250
29	81	84	1999-2000	Maximum hoop size of 6" Trap limit reduced from 275-250
30	81	82.5	1999	Maximum size on females 135mm
31A	81 86 84	86 84 82.5	1998-2000 2004 2007	114-124 Window size for females (started 1998-2000)
31B	81 82.5 84	82.5 84 82.5	1998 1999 2000	110 lb females v-notched and returned (started 2000)
32	81	82.5	1999	110 lb of females v-notched and returned (started 2000)
33	81	82.5	1998	

* There is a possession restriction of V-notched lobsters in all LFAs except in LFA 27 and LFA 31A

All lobster fishing areas are presently developing IFMP and harvest plans. Part of these includes development of a Precautionary Approach (PA) with reference points.

2. IDENTIFICATION OF STOCK ASSESSMENT UNITS

2.1 INTRODUCTION

Previous assessments of lobsters in LFAs 27-33 have been primarily LFA-based. The last time these stocks were assessed there were four separate research documents and three stock status reports (Eastern Cape Breton Lobster - LFAs 27-30, Eastern Shore Lobster - LFAs 31A, 31B, 32, and South Shore Nova Scotia Lobster - LFA 33). While virtually all of the data on lobster populations in coastal Nova Scotia comes from the fishery in the individual LFAs, there is merit to moving towards larger units that have some basis in biology and common population trends. FRCC (1995) advocated this and recommended Lobster Production Units (LPAs) which were not adopted for several reasons.

In the USA stock definitions were based on reviews of lobster distribution and abundance, patterns of migration, location of spawners, and the dispersal and transport of larvae (ASMFC, 2006, 2009). Three large stocks were identified: Gulf of Maine (GOM), Georges Bank (GBK), and Southern New England (SNE).

In the Maritimes, the above criteria could be used now to separate the southern Gulf of St. Lawrence from the Canadian Gulf of Maine. The challenge here is to identify stock assessment units for Atlantic Nova Scotia. A single assessment unit is not appropriate given differences in size at maturity (see companion research documents on size at maturity) and fishing seasons. Fishing seasons are in part based on climate differences – ice usually prevents fishing in the winter off eastern Cape Breton.

For the purposes of this assessment, a working definition of assessment units within LFAs 27-33 (Fig. 2.1) is based on lobster landings trends together with size at maturity estimates. In the 1980s and early 1990s there were several papers on lobster landings in coastal NS and the Maritimes (Campbell and Mohn 1983, Harding et al1983, Pezzack 1992, Hudon 1994). The most recent of these uses landings data only up until 1991. These analyses are predicated on the assumption that landings bear some relationship with abundance. We continue to subscribe to this view, although landings have also been affected by year to year changes in lobster availability and changes in fishing efficiency. Three stock areas can be recognized based on the earlier papers: north-eastern Cape Breton (LFA 27); southeast Cape Breton and eastern shore (LFAs 29-32) and south shore (LFA 33). LFA 28 (Bras d'Or Lake) was not part of these analyses, as historically landings were not kept separate for this LFA. Claytor et al. (2001) examined landings trends within LFA 33 for the period 1947-2000 and recognized a split between the eastern and western portions of LFA 33 similar to some of the earlier studies examining landings from larger spatial areas.

Here we apply cluster analysis to landings from 1947-2009 to determine the extent to which the above groupings stand.

2.2 METHODS

2.2.1 Landings Data

Annual landings data were tabulated on the basis of Statistical District (SD, Fig. 2.1). Lobster landings data from 1947-1989 came from Williamson (1992) which Williamson compiled from data from Statistics Canada (1892-1976) and the DFO Statistics Branch, Halifax. Data for the period 1990-2009 were extracted from Oracle database tables. The ZIFF (Zonal Interchange File Format) database includes lobster landings by Statistical District, port and date in a series

of tables aggregated by year since 1989. For the period 2003-09, lobster landings were accessed from archived and production components of the MARFIS (Maritime Fishery Information System) database. For landings data in SD 1 data from DFO's Gulf Region was accessed (SD 1 spans both the Maritimes Region and the Gulf Region).

To gain a broader perspective on spatial differences in landings trends, SD outside of LFAs 27-33 were included in the analysis. Landings data from LFAs 34-38 were included as were data from LFA 26b (obtained from the Gulf Region - M. Comeau, pers. Comm.). Landings from the state of Maine were also included (obtained from http://www.maine.gov/dmr/rm/lobster/lobdata.htm and the recent US lobster assessment document (ASMFC, 2009)).

2.2.2 Cluster Analysis

The cluster analysis was set up to group statistical districts with similar landings trends over time. Analyses were performed using the "cluster" package for R. First a correlation matrix was calculated. This consisted of the correlations of each SD with all other SD for the landings from 1947-2009. This was translated to a distance matrix by subtracting each correlation coefficient from 1. Wards hierarchical agglomerative clustering method was then applied. This clustering approach is the same as that used in Hudon (1994). Note that this method results in clusters of SD with similar landings trends regardless of what the landings levels were. For example if area A started with 100 tons per year and gradually increased by 5 tons per year for 20 years, and area B started with 10,000 tons per year and gradually increased by 500 tons per year for 20 years, areas A and B would cluster in the same group.

To evaluate the effect of what landings time period is used in the cluster analysis, the same analysis was run with landings from (i) 1985-2009; and (ii) 1947-1984.

Standardized Landings

To depict landings patterns by SD, landings were standardized by subtracting the mean for the SD and dividing by the standard deviation. This removed differences in the level of landings and so depicted the trends detected in the cluster analysis.

2.3 RESULTS

The cluster dendogram is shown in Fig. 2.2. Three to six cluster groups can be recognized. The three most well defined clusters, which separate at a height of about 1.5 units, are as follows.

- **Cluster A:** a group of SD in northeastern Cape Breton, the south shore of Nova Scotia and southwest Nova Scotia (LFA 34).
- **Cluster B:** a group of SD in the Bay of Fundy together with the state of Maine.
- **Cluster C:** SD in southeastern Cape Breton and the eastern shore to Halifax.

Looking at the 6-cluster level, SD 22-28 on the south shore of NS separates from the remainder of cluster A. SD 30 and 31 on the south shore (Shelburne county) remain with cluster A1, similar to an earlier cluster analysis by Hudon (1994). Halifax area separates from cluster C and the Bay of Fundy separates into two groups of non-adjacent SDs.

Plots of standardized landings for the 6 clusters show cluster specific trends since 1947 (Fig. 2.4). Cluster group A can be characterized by a rapid increase beginning around 1980 with a drop off sometime in the last 10-20 years. Cluster group A2 differs in that there was a distinct downward trend from 1947 to about 1980. Cluster group B can be characterized by a more or less steady increase since 1980. Cluster group C1 differs in that there was a peak in landings in the 1950s followed by a decline until about 1980, a secondary peak in the 1990s and a sustained increase in the last 6 years. Landings in cluster group C2 have been more erratic but also showed a peak in the early years with a low around 1980.

1985-2009 Clusters

The cluster groups resulting from the analysis of landings from 1985-2009 (Fig. 2.5 and 2.6) were very similar to those resulting from the analysis using the full 63 year time period. Four clusters can be recognized at a height of 1.5 units:

- **Cluster A1':** Northern Cape Breton and parts of SW Nova Scotia. Similar to A1 in the analysis of landings for all 63 yr.
- **Cluster C1:** SE Cape Breton and the eastern shore - same as C1 in the analysis of landings for all 63 yr.
- **Cluster B':** Bay of Fundy. Virtually identical to Cluster B in the analysis of landings for all 63 yr.
- **Cluster A2':** south shore plus western part of the eastern shore (Halifax County). Similar to A2 d in the analysis of landings for all 63 yr.

The main difference in the two analyses was in the membership of some SD in Halifax County and in Shelburne County. SD east of Halifax were closer to the eastern shore in the analysis of landings for all 63 yr, but were grouped with the south shore in the analysis based on the more recent years.

1947-1984 Clusters

The cluster groups resulting from the analysis of landings from 1947-1984 (Fig. 2.7) were a mix of clusters seen in the analysis using the full 63 year time period. There was still a tendency for adjacent SD to cluster together (e.g. SE Cape Breton and eastern shore; SD 4, 6 and 7 in Cape Breton), but overall the cluster groups were not spatially coherent.

2.4 DISCUSSION

The clusters resulting from the analysis of the 1985-2009 period were very similar to the clusters resulting from the analysis of the 1947-2009 but this was not the case for the clusters based on the 1947-1984 period. This suggests that the landings trends in the last 25 years had relatively more weight in the analysis than earlier years. This is likely due to the substantial increases in landings that occurred in many areas in the last 25 years.

The clusters identified based on landings trends are similar to those identified in earlier analyses. Hudon (1994) considered only SD 1 to 34 and the years 1947-1991 and identified a cluster containing northern Cape Breton and southwest NS (our cluster 1A). For comparison we used the same SD and the same years as Hudon (1994) and obtained virtually identical groups (Fig. 2.8). Hudon (1994) also looked at landings per km of shoreline and identified cluster A as

having the highest landings per unit of coastline and suggested higher degree days may be the cause.

The current analysis extends what Hudon (1994) did in that it shows the linkages between Cape Breton and the southern Gulf (LFA 26b in Cluster A). The current analysis also identifies a different pattern of landing in the Bay of Fundy compared to southwest NS.

The suggestion that western Cape Breton in the southern Gulf is linked to northeastern Cape Breton is reinforced by the similar sizes of maturity in western Cape Breton (72-75 mm CL; Table 3 in Comeau et al. 2008) and LFA 27 (72-75 mm CL – Section 3). In addition recent models of larval lobster transport indicate that some larvae produced in the southern Gulf are transported around Cape North to the shores of northeastern Cape Breton (J. Chasse, pers. comm.).

Landings trends in SE Cape Breton and the eastern shore (Cluster C) are substantially different from those in northern Cape Breton and southwest Nova Scotia. This area is characterized also by a relatively high catch rate of ovigerous females (Tremblay et al. 2009).

The Atlantic coast of Cape Breton and Nova Scotia may be best thought of as a transitional zone between the lobster stocks in the Southern Gulf of St. Lawrence and the Gulf of Maine. These two areas differ substantially in terms of size at maturity and seasonal cycles of production (the southern Gulf has ice in winter). It is of interest that the recent genetic study by Kenchington et al. (2009) identified two broad regions. One was centered in the Gulf of St. Lawrence and one in the Gulf of Maine. The line separating the two was on the south shore close to where clusters 1a and 1b separate in Fig. 2.3.

Current studies are now getting underway to better define connectivity across Atlantic lobster stocks. These studies will be undertaken as part of the NSERC-funded Canadian Capture Fisheries Network. Work is in progress on (i) lobster larvae transport models and (ii) genetic analyses of adaptive markers. As such the assessment units derived below may be modified in the future.

Assessment Units for 2011 Assessment

Indicators and reference points will be developed for the following assessment units. Some or all of the indicators will also be summarized for smaller assessment subunits. In some cases these will be LFAs; in other cases parts of LFAs.

1. Northeastern Cape Breton (LFA 27)
2. Southeastern-Cape Breton, Chedabucto Bay and eastern shore
3. South Shore

LFA 28 is fished by few fishermen and has had low landings for many years. It has been grouped mainly with LFA 29 in the past. The landings trend over the last 7 years does not suggest an increase in abundance similar to the adjacent LFA 29. As such it may make more sense to group it with LFA 27. The physical oceanography suggests a closer link with LFA 27 in that the current flow is stronger through Barra strait (into the Northern Basin, which is part of LFA 27) than through St. Peters Inlet into LFA 29 (Petrie and Bugden, 2002).

Two of the above assessment units are further subdivided for some analyses: LFA 27 north (SD 1-4 and LFA27 south (SD 6, 7) and LFA 33 (east and west). Several of the above studies noted that landings in the northern portion of LFA 27 were distinguishable from those in the

southern portion, and both Hudon (1994) and Claytor et al (2001) concluded there was a difference in landings patterns between the eastern and western portions of LFA 33.

2.5 SUMMARY

A cluster analysis of historical lobster landings (1947-2009) for Statistical District (SD) was used to group LFAs for assessment purposes. The resultant groups had similar trends in landing over the last 63 years. Cluster groups resulting from an analysis with just the data from 1985-2009 were similar to those from the analysis of landings from the 63 year period.

The assessment units will be as follows:

1. Northeastern Cape Breton (LFA 27)
2. Southeastern-Cape Breton, Chedabucto Bay and eastern shore (LFA 29-32)
3. South Shore (LFA 33)

Where appropriate, data will be presented for subunits of the above units.

2.6 FIGURES

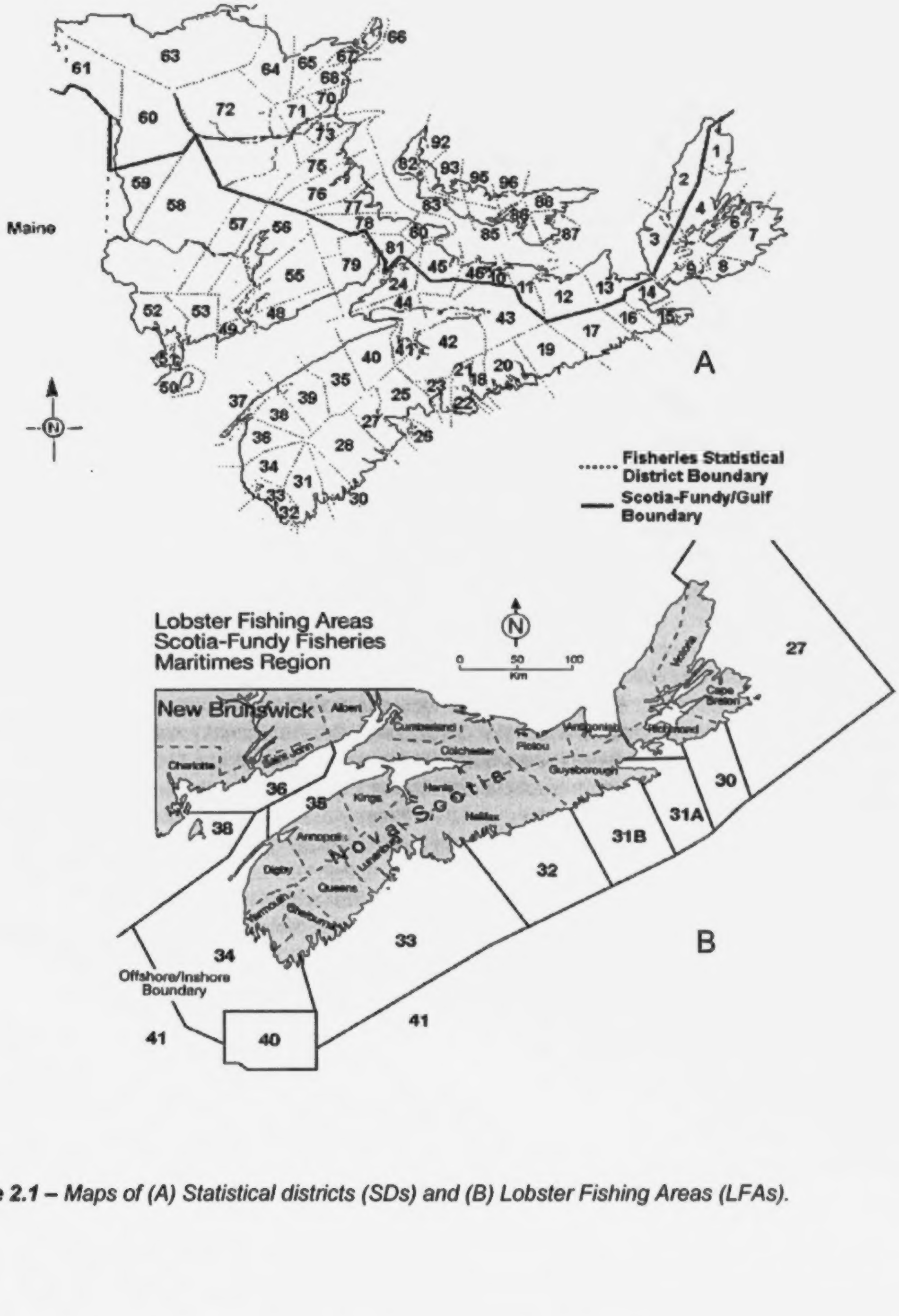


Figure 2.1 – Maps of (A) Statistical districts (SDs) and (B) Lobster Fishing Areas (LFAs).

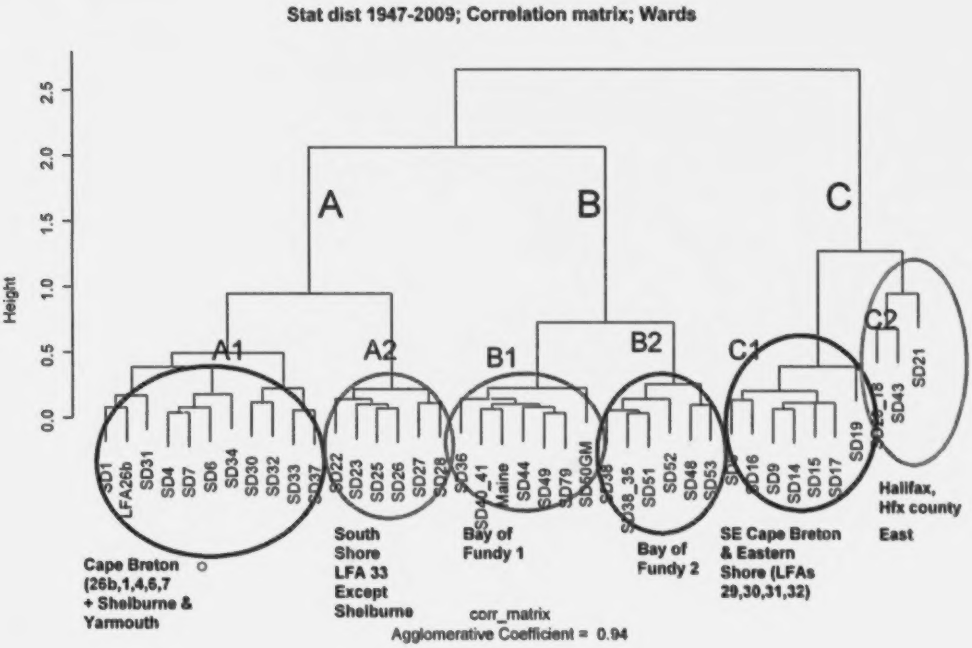


Figure 2.2 *– Cluster analysis dendogram of Statistical District (SD) landings data, 1947-2009. Three high level clusters (A, B, C) and 6 lower level clusters are identified.*

```
SD_landings<-read.table("SD_land_1947_2009_for_cluster.txt",na.strings = "NA",header=T)
corr_matrix<-as.dist(1-cor(SD_landings,use="pairwise.complete.obs"))
cluster1<-agnes(corr_matrix, method = "ward")
plot(cluster1,main="Stat dist 1947-2009; Correlation matrix; Wards")
```

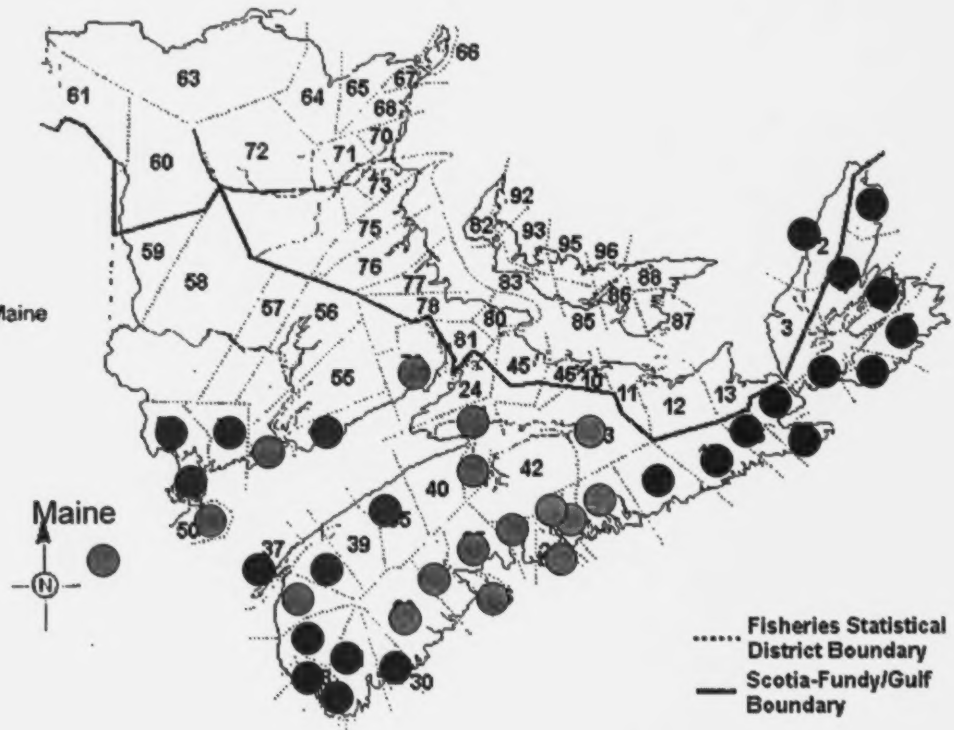
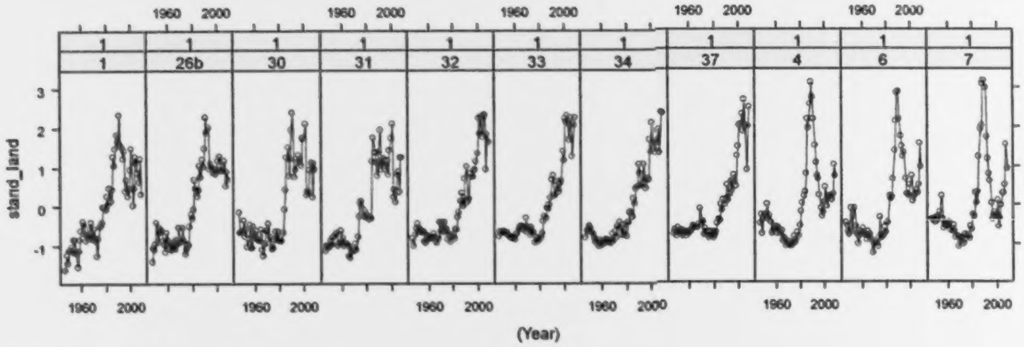
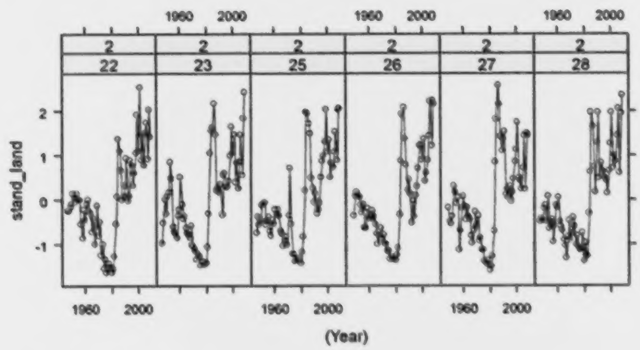


Figure 2.3 – Clusters of Statistical districts resulting from analysis of landings data from 1947-2009. SD are color-coded according to clusters dendogram in Figure 2.2.

A1. Cape Breton, Shelburne and Yarmouth



A2. South Shore except Shelburne



B1. Bay of Fundy 1.

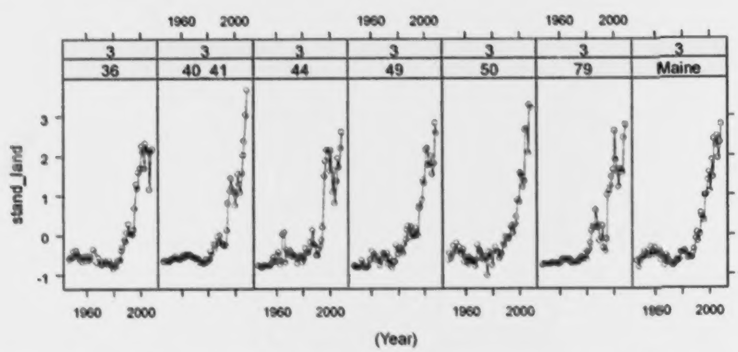
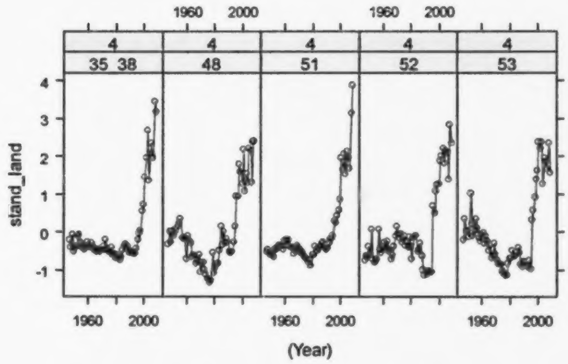
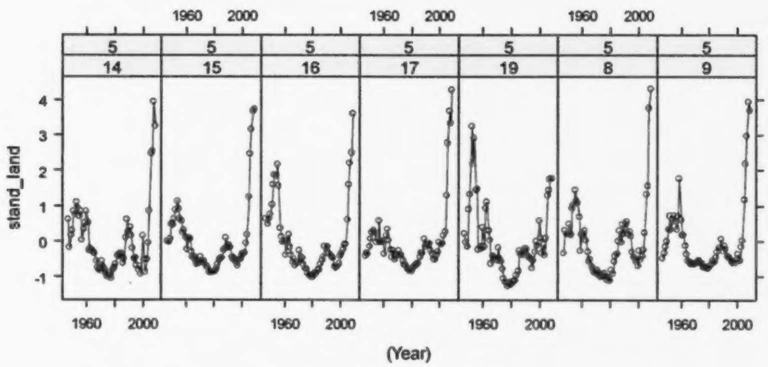


***Figure 2.4** – Landings trends 1947-2009 by cluster group and SD. Landings are standardized to mean of 0.*

Bay of Fundy 2



SE Cape Breton & Eastern Shore (LFAs 29,30,31,32)



Halifax and Halifax county East

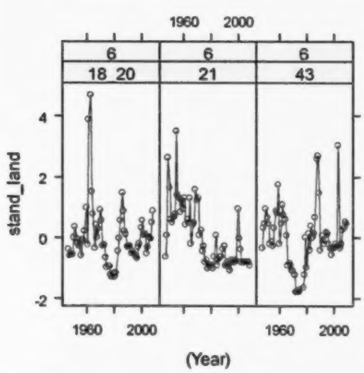


***Figure 2.4 (cont'd)** -- Landings trends 1947-2009 by cluster group and SD. Landings are standardized to mean of 0.*

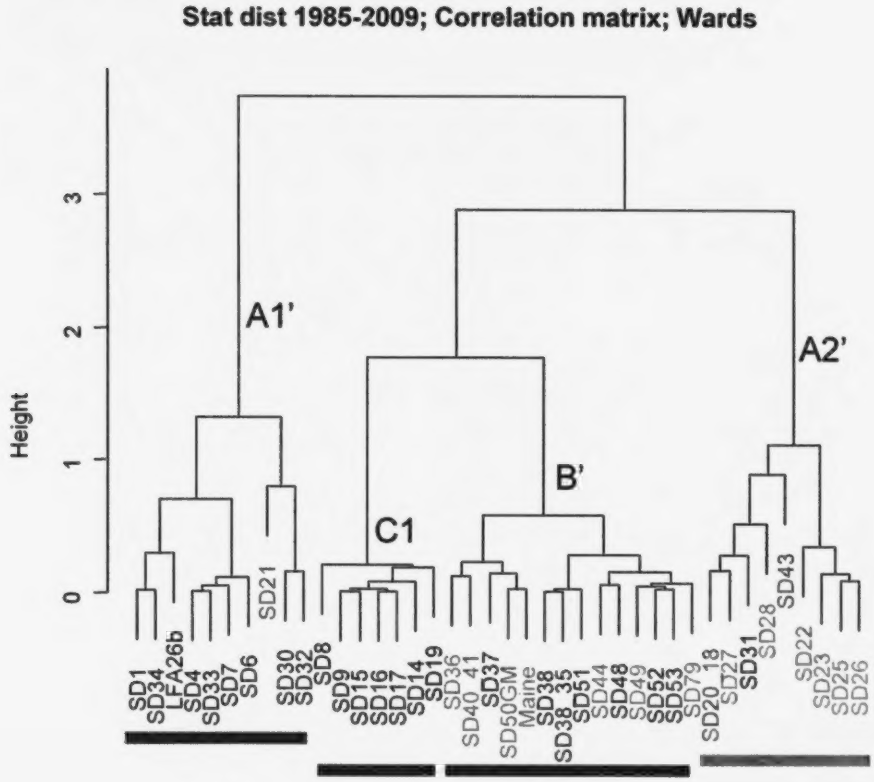


***Figure 2.5** – Cluster analysis dendogram of Statistical District (SD) landings data, 1985-2009. SD are colour-coded according to the clusters depicted in Figure 2.2 and 2.3. Colour of bars at bottom of figure corresponds to colour codes in Figure 2.6.*

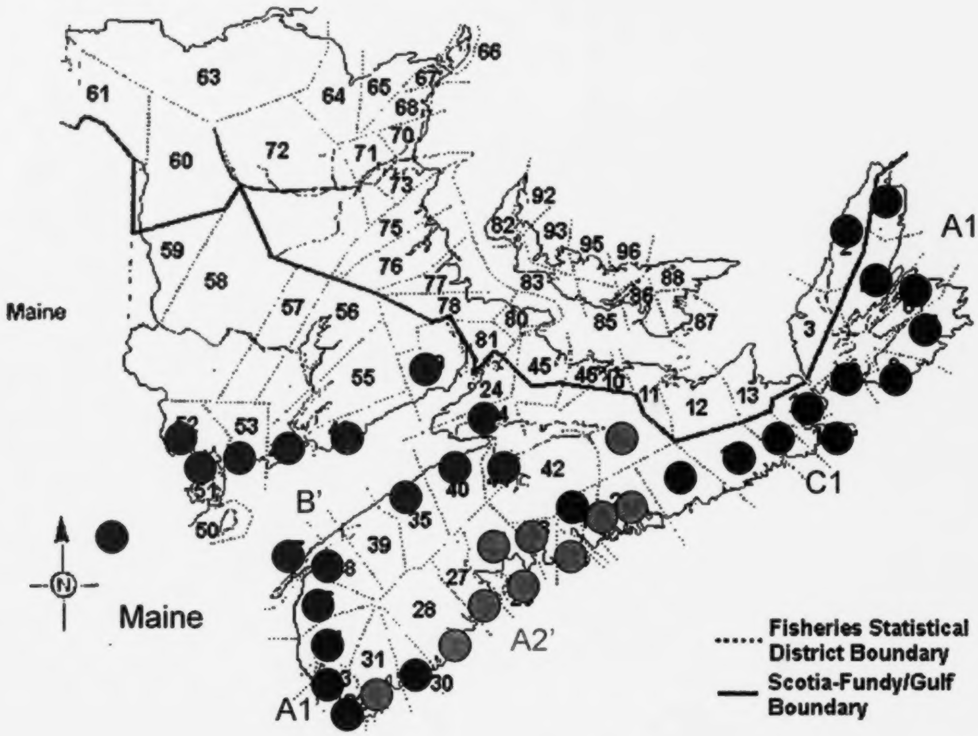


Figure 2.6 – Clusters of Statistical districts (SD) from analysis of landings from 1985-2009. SD are color-coded according to whether they were in cluster A1', C1, A2', or B'. See Figure 2.5.

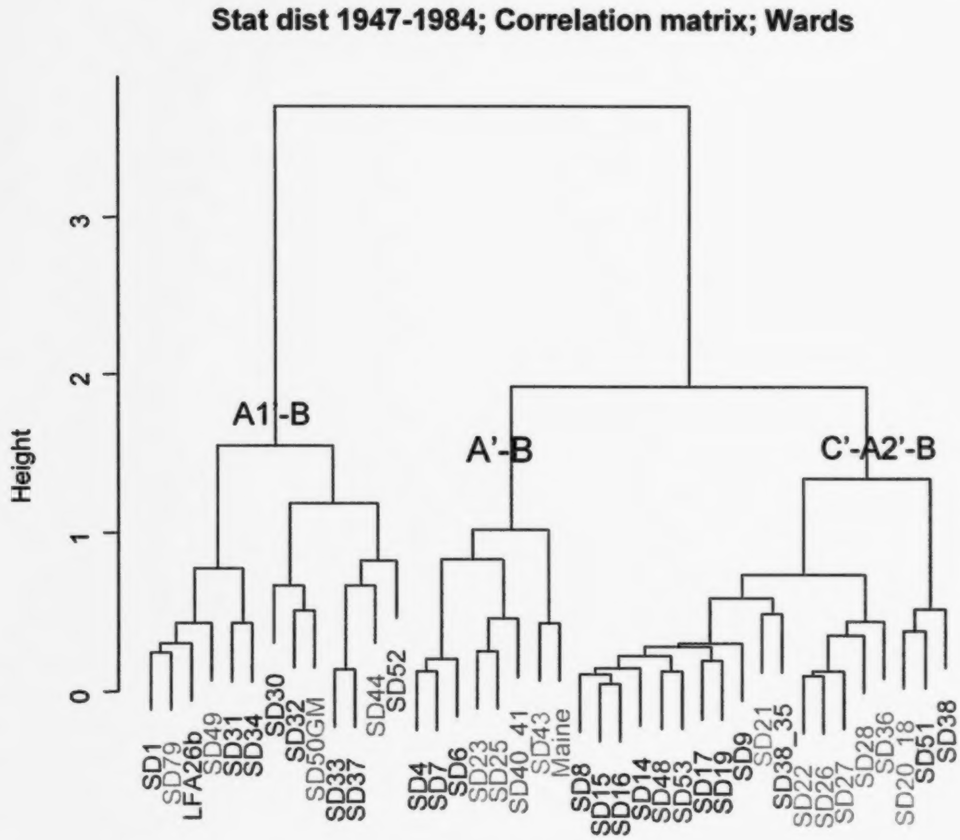


Figure 2.7 *– Cluster analysis dendogram of Statistical District (SD) landings data, 1947-1984. SD are color-coded according to the clusters depicted in Figure 2.2 and 2.3.*

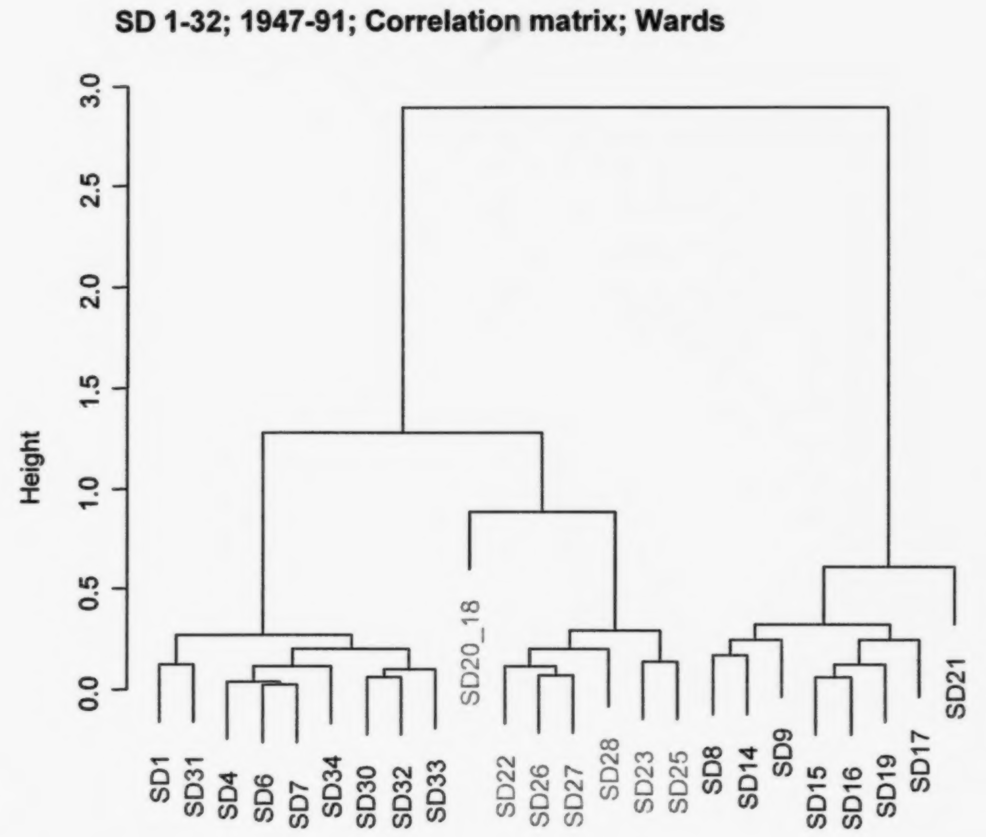


***Figure 2.8** – Cluster analysis dendogram of landings data for Statistical District (SD) 1-34, 1947-1991. This is the same data used by Hudon (1994). Resultant clusters are nearly identical to those in Hudon (1984). Here the SDs are color-coded according to the clusters depicted in Figure 2.2 and 2.3.*

3. DATA INPUTS

3.1 LANDINGS AND EFFORT DATA

3.1.1 Mandatory Reporting

Landings data from 1892 to 1946 were derived from historical records. These data are by calendar year and are summarized by county (Figure 3.1). Landings from 1947 to 1995 are based on sales slip information from buyers and are summarized by Statistical District (Figure 3.2). The mandatory catch reporting system changed in 1995/1996 from a system based on dealer sales slips to one based on individual fishermen sending in monthly catch settlement reports. For all LFAs, the catch settlement report only provided information on daily catch by port landed and date of landing. Thus, landings data were reported by LFA, Statistical District or port landed. In November 1998, as part of their lobster conservation plan, LFA 34 fishermen adopted an expanded catch settlement reporting system, called the Lobster Catch and Settlement Report (Appendix 3.1) which required them to provide information on daily catch and effort by reference to a grid system (Figure 3.3). Similar data were obtained in 2004 and 2005 during a pilot project in LFAs 27-32. Beginning in 2006 (2005-06 for LFA 33) a Lobster Catch and Settlement Report was introduced to all fishermen in LFAs 27-33 and participation rates have increased since (see below).

Reported landings for LFA 28 are historically variable and low, ranging from 5-15 mt from 1990 to 2001 (Tremblay and Reeves, 2004) and from 7-13 mt in more recent years Validating the landings for LFA 28 prior to 1990 is not possible and we are most confident in landings since 1995.

Lobster landings data prior to 1986 were obtained from Statistics Canada (1892-1976) and the DFO Statistics Branch, Halifax and are summarised in Williamson, 1992. From 1986 to 2001 lobster landings data were accessed from Oracle database tables created by DFO's Marine Fisheries Division from data compiled by DFO Statistics Branch into the ZIFF (Zonal Interchange File Format) database. The ZIFF database includes lobster landings by Statistical District, port and date in a series of tables aggregated by year since 1986 (called Identified_catches_YYYY). As of 2002, lobster landings were accessed from archived and production components of the MARFIS (Maritime Fishery Information System) database. Landings from the Gulf Region portion of LFA 27 were obtained from the Gulf Region lobster group.

Changes in reporting systems in 1995/1996 and 2006-2008 may influence accuracy and completeness of landings. Landings prior to 1996, based on sales slips, may have missed a portion of the catch sold directly to consumers or sold directly in the USA. The size of the underestimation is not known. Post 1996 landings, reported by fishermen directly, should be more complete however no detailed analysis has been done to determine completeness or accuracy of reports. Thus changes observed since 1996 must be viewed in light of the change in reporting methods.

Estimates of reporting levels have been completed for LFAs 27-33 on the Self Reporting system and the currently used Lobster Catch and Settlement Reports for 2004 to 2010 (Table 3.1). The percent of licence holders reporting was calculated by counting the number of licence holders reporting per month and dividing that by the total number of licences in that LFA. Even if a licence holder only reported once within a month (one day fished) it was counted as a reporting licence for that month. In the case where the calculation was done on the sub units of LFA 33 (LFA 33 East and LFA 33 West) the total number of licences was based on the homeport of the

licence holder according to the DFO licensing records as of 2010. If the homeport did not fall within LFA 33, it was based on the port of landing from the Lobster Catch and Settlement Report. There were 29 of 705 licences that had a non LFA 33 homeport in 2010. The activity of licences has varied over years, so the 2010 list is not an exact match to previous years. The additional active licences vary from 2 to 10 from 2004 to 2010. The licence allocation was based on the licence list as opposed to the port of landing due to the high number of records without a port of landing in LFA 33 (up to 5%). In LFA 27, there were less than 1% (average 0.1%) of the records without a home port. Therefore, the LFA 27 sub unit (LFA 27 North and LFA 27 South) licence numbers were based on port of landing.

To estimate reporting levels of effort, we calculated the percentage of logs jointly reporting trap hauls and landings information (Table 3.2). This was done by dividing the total number of records reporting weight and effort by the total number of records reporting a weight. This excludes records with no weight and no trap hauls, which is valid for a month where there was no fishing activity by a licence holder. The percentage of licence holders reporting effort increased significantly between 2006 and 2008, reflecting the phasing in of the current logbook system which requires the reporting of effort.

To estimate the levels and accuracy of grid location reporting, the total number of records reporting weight and a valid grid number was divided by the total number of records reporting a weight (Table 3.3). A valid grid number is one which is within that licence holder's LFA according to the grid map provided with the Lobster Catch and Settlement Report. Again, only the number or records with a weight reported were used as the denominator to exclude nil fishing activities.

In LFA 27, only data from MARFIS was used for calculating reporting levels, which does not include the Gulf portion of landings for LFA 27.

For 2002 to present, landings reported by LFA were taken from the Slip portion of the MARFIS database. This represents the actual amount of lobsters sold on a particular date. Where effort or locations are included, the data has been taken from the Log portion of the MARFIS database. These are the data that the fisherman report on each day fished. Landings from this portion are an estimate. In most cases, the difference between the total Slip data and Log data are less than 10% and an annual basis for LFAs 27-32 and a seasonal basis for LFA 33 (Table 3.4). There are several factors that might account for these differences between the slip and log reporting. These include illegal landings, unreported landings, general misreporting, non-reporting of nil fishing activity, etc.

For mapping purposes, only data with valid grids reported in the log were used. This represents an average of 93% of the data from 2008 to present (Table 3.3). The data was assigned a central latitude and longitude for each grid.

Data Sources	Dates	Sales	Daily Catch	Daily Effort	Location
Sales Slips	Pre fall 1995	X			Port Statistical Area
Self Reporting Landings	Fall 1995/1996-2004	X	X		Port Statistical Area
Compulsory Logs (Lobster Catch and Settlement Reports	2004-present (Phased in with time varying with LFA)	X	X	X	Grid Area Port Statistical Area

3.1.2 Voluntary Reporting

From 1981 to 2009, index fishermen kept fishing logs of daily catch and effort (number of trap hauls per day). Selection of participants was not random and was based on their willingness to contribute their information. It is assumed that annual fluctuations in the catch rates of logbook keepers reflect the fishery as a whole. All voluntary log data resides in a portion of the LOBBIO database.

The number of participating fishermen has varied within area and year (Tables 3.5 and 3.6). For the three most recent years available for LFA 27-32 (2007-2009), participation has ranged from 17-28 fishermen. This is down from a high of 103 participants in 1994. In LFA 33, for the three most recent seasons available (2004/2005 to 2006/2007), there were about 20 participants. This is down only slightly from a high of 27 in 2001/2002. Voluntary logbook data for LFA 33 is not available for the most recent seasons.

3.2 AT-SEA SAMPLES OF THE COMMERCIAL CATCH

At-sea samples collect information from fishermen's catch during normal commercial fishing operations. The data collected includes: carapace length measured to the nearest millimetre (from the back of eye socket to the end of the carapace), sex, egg presence and stage, shell hardness, occurrence of culls and v-notches, and number, location and depth of traps. See Appendix 2 for sampling protocol.

At-sea sampling provides detailed information on lobster size-structure in the traps (including sub-legal, berried, and soft-shelled lobsters). As all lobsters retained in each trap haul are measured, the numbers caught can be converted into estimates of the catch rate of legal-sized animals by weight from known length-weight relationships.

At sea lobster data from 1947 to 2000 were obtained from the LOBBIO database. This database was used for data storage prior to the CRIS system. Data is available as a sexed length frequency on a trip basis. A total number of traps hauled and one location can be provided for the trip.

Additional data from this time period and from 2001 to present were obtained from the CRIS (Crustacean Research information System) database. This present at-sea database has the ability to capture depth, location, soak days and other details on an individual trap basis. For each lobsters, the database captures a carapace length, sex, shell hardness and selected other characteristics.

The numbers of samples and their storage location is available in Table 3.7 and 3.8.

In 2008, a Species at Risk Act (SARA) initiative began to collect bycatch data from lobster fishing activities. During these sampling trips, all bycatch was examined. In addition, all lobsters and crabs were measured and sampled. See Appendix 3 for the SARA sampling protocol for lobster. The SARA data was entered into the ISDB (Industry Survey Database) which is a Department of Fisheries and Oceans database that includes at-sea catch observations from commercial fishing vessels. Queries on the ISDB tables were developed to produce outputs similar to that from the CRIS database allowing integration of the two datasets. During 2008-2010, approximately 269 SARA samples were completed in the LFA 27 – 33 lobster fisheries (Table 3.9).

The at-sea data set used in this assessment includes only targeted lobster trips. Non targeted trips (rock, Jonah, green, stone crab) would only add another 554 lobster measurements from 1985 to present, LFA 27-33.

3.3 PORT SAMPLING OF THE COMMERCIAL CATCH

During port sampling, a fisherman's landed catch is measured (carapace length), and sexed. On average, each sample includes up to 6 crates of lobster, or the fisherman's catch for the day. This information is captured on a voice recorded and later transcribed onto paper for data entry into the LOBBIO database. In the past, location of the samples was available only at the level or port landed. However, in more recent years, whenever possible the fishing grid from the Lobster Catch and Settlement Report is associated with the sample. A summary of the numbers of port samples completed by year and LFA is available in Table 3.10.

3.3 FSRS RECRUITMENT TRAPS

The Fishermen and Scientists Research Society (FSRS) recruitment trap project involves volunteer fishermen keeping track of the lobsters caught in project traps. Fishermen participants use standard traps and a standard gauge to assign each lobster captured to a size group. Participants in the project are distributed along the Atlantic coast of Nova Scotia (Figure 3.4). The number of participants in LFAs 27-33 was 67 in 1999, but increased steadily to 132 in 2006. The number of participants was 122 in 2009. Table 3.11 shows the number of participants by LFA and year / season for 1999-2009.

Participants record size, sex and presence of external eggs for all lobsters collected in standard traps on each day of commercial fishing. Soak times were usually one day except during the winter period (LFA 33 only). Compared with commercial traps, the FSRS wire traps have features that lead to greater retention of prerecruit lobsters: smaller mesh size (2.5 cm), smaller entrance rings (12.5 cm), and no slots to allow sublegal sized lobsters to escape. As such, the FSRS traps provide a better indication of the abundance of prerecruit lobsters than commercial traps. Since the traps are the same throughout the study area, they allow for a better comparison between areas that may have several different designs of commercial traps. Lobster measurements were made with an FSRS gauge that facilitates data collection in the field by fishers.

Fishermen were asked to set the traps in one location throughout the season. Most fishers were able to comply, but as commercial traps in some fishing areas are moved substantial distances over the course of the season, sometimes standard traps were moved as well. In these instances, fishers noted the location changes and these were later recorded in the database. The standard traps were equipped with temperature recorders that provided data on nearshore bottom temperatures (Tremblay et al. 2007).

Size groups (as of fall 2003) are listed below:

Size 1 (less than 11mm)
Size 2 (11mm – 20.9mm)
Size 3 (21mm – 30.9mm)
Size 4 (31mm – 40.9mm)
Size 5 (41mm – 50.9mm)
Size 6 (51mm – 60.9mm)
Size 7 (61mm – 70.9mm)
Size 8 (71mm – 75.9mm)

Size 9 (76mm – 80.9mm)
Size 10 (81mm – 90.9mm)
Size 11 (91mm – 100.9mm)
Size 12 (101mm – 110.9mm)
Size 13 (111mm – 120.9mm)
Size 14 (121mm – 130.9mm)
Size 15 (greater than 131mm)

Size groups 8 and 9 are in 5mm increments to give a clear indication of the number of lobsters just under the legal size limit. Fishermen also record whether the lobster is legal sized, its sex and the presence of eggs.

Prior to 2003 the size groups ran from size 1 (less than 51mm) to size 8 (101mm and greater). Fishermen participants use standard traps and a standard gauge to assign each lobster captured to a size group. Size groups are listed below:

Size 1 (less than 51mm)
Size 2 (51mm – 60.9mm)
Size 3 (61mm – 70.9mm)
Size 4 (71mm – 75.9mm)
Size 4.1 (sublegal lobsters 71mm – 75.9mm)
Size 4.0 (legal lobsters 71mm – 75.9mm)
Size 5 (76mm – 80.9mm)
Size 6 (81mm – 90.9mm)
Size 6.1 (sublegal lobsters 81 – 90.9mm)
Size 6.0 (legal lobsters 81-90.9mm)
Size 7 (91mm – 100.9mm)
Size 8 (101mm and greater)

Data Sources	Fishing Location	Depth	Lobster Size	Sex	Berried Females	Sublegal Sizes	Window Max Size	V-notch	Trap Type	Bycatch	Sclae of Measure	Timing
Port Samples	Port		X	X							1mm	Periodic but variable
At Sea Samples	Lat/Long	X	X	X	X	X	X	X	X	X	1mm	Periodic but variable
FSRS	Lat/Long	X	X	X	X	X	X		X		10mm 5mm	Daily

3.5 STRENGTHS AND WEAKNESSES OF THE DATA SOURCES

The major types of data used are fishery catch and effort and lobster size data from commercial traps and lobster catch data from standard traps fished by FSRS participants. There are various methods for obtaining them and each source has its strengths and weaknesses, which need to be understood in planning data collection and in the analysis and interpretation of results. The tables below briefly summarize these with more detail discussion in the sections describing the analysis and interpretation of the data.

Sources of catch and effort data:

	Strength	Weakness	Issues
Self Reporting Landings (1995-2004)	Daily catch for all fishermen	No effort information Limited location information (Port of sale) Variable trap design No SOD recorded Limited quality control Short time series (1995-2004)	These were a transition from sales slips (landings only) to the full logs with effort and location The completeness of the landings reported is unknown and may vary temporally and spatially
Compulsory Logs (2005-present)	Daily catch and effort for all fishermen Location information by grids fished High compliance rate in recent years Data entered by Dockside Monitoring companies and available within 1 month of logs submitted (logs submitted monthly)	Short time series (< 5 years) Variable trap design No SOD recorded but can be calculated if all traps are hauled each data Initial low compliance rate Limited quality control initially but ongoing efforts to improve it. Reliability of data can be influenced by potential management implications No place for berried lobsters (though when tried in earlier logs data was provided inconsistently and proved not useable)	While accuracy of some individual logs may be questioned overall trends are believed reliable. Some problems exist with missing, incorrect or nonexistent grids, errors in port or Statistical area and unrealistic values for catch and effort Improved quality control of the data provided by fishermen and in data entry could reduce these problems. Efforts have been made to do this with positive results but some problems still exist Data can be edited to eliminate extreme values or a sub sample taken of fishermen with consistently reported complete information
Voluntary Logs (1984-present)	Includes daily catch and effort of each participant Additional information can be recorded (i.e. berried females) Long time series	Voluntary with numbers low and declining over time Distribution based on location of volunteers so large areas not covered. Volunteers may not be representative Variable trap design Variable location information No SOD recorded Not a standardized data form so data recorded varies and data entry is more time consuming	Provided valuable information on catch rates prior to the introduction of the compulsory logs and could be used along with the compulsory logs to extend the catch rate time series. A period of overlap would be needed to do the analysis needed. Following the introduction of compulsory logs the participation rate declined in most LFAs and the usefulness of continuing this program has been questioned.
FSRS Juvenile Traps	Catch and effort and size recorded for each fishing day Distributed over much of the coast Standardized traps Theoretically fixed location Temperature data available for each fisherman Moderate time series in most areas (1999-present	Trap designed for small lobsters so may under represent larger sizes Total trap numbers low with only two traps per fisherman so it does not represent entire catch Voluntary and subject to changes in participants and participation rates Deeper water areas further from coast under represented. Trap locations chosen by fisherman and theoretically not moved	The traps provide a powerful tool providing data from a wide area over the entire season. As a voluntary system interest and dedication by the fishermen is key. Changes in participation rates would jeopardise the time series so depending solely on this data source may not be recommended
FSRS Commercial Traps (data not used in this Framework assessment)	Catch and effort and size recorded for each fishing day Temperature data available for many	Trap dsign variable Small number of participants in LFA 33 only Total trap numbers low so does not represent entire catch Moderate time series Voluntary and subject to changes in participants and participation rates Locations chosen by fisherman	As a voluntary system interest and dedication by the fishermen is key. Changes in participation rates would jeopardise the time series.

Sources of size data:

	Strength	Weakness	Issues
Port Samples	Low cost per sample and logistically simple to undertake Ability to sample several vessels catch in a day providing a potential for samples representing a wide area around the port Provides sizes of landed catch	Only the landed catch with no sublegal, window, oversize, berried females or v-notch lobsters A subsample of the fisherman's catch and may not represent entire catch No exact measure of effort, or location No bycatch data	The time series varies with LFA and with a few exceptions generally lack long term consistent sampling.
At sea samples	Entire catch available to sample including sublegal, berried, v-notched, window and oversize. By-catch data available Exact location and depth Trap by trap effort allows for calculation of CPUE Shell condition data collected	High sample cost Limited to one vessels catch per day In areas or time periods with low catch rates sample sizes are too small and additional samples required. Weather dependent Additional training required for samplers and potential workplace health and safety issues	The high unit cost has meant that the number of samples is low and in recent years has needed support from industry funding or special short term government funds. The time series varies with LFA and with a few exceptions, generally lack long term consistent sampling. Only sampling method that provides detailed information on non landed portion of the catch
FSRS Recruitment traps	Sampled each fishing day over the entire season Distributed over much of the coast Known location and depth Temperature data available for each fisherman Moderate time series in most areas (1999-present	Size groupings of 5 and 10mm Traps designed for pre-recruits and may under sample larger sizes Total trap numbers low with only two traps per fisherman so it does not represent entire catch Voluntary and subject to changes in participants and participation rates Deeper water areas further from coast under represented. Locations chosen by fisherman and may not represent the entire catch	The traps provide data from a wide area over the entire season. As a voluntary system interest and dedication by the fishermen is key. Changes in participation rates would jeopardise the time series The large size groupings make it easy for fishermen to measure but they also reduce the ability to track smaller size changes and the sizes units do not always correspond with minimum, maximum or window sizes. The traps were designed for smaller sizes and may reduce the catch of larger sizes. This becomes a concern in areas where larger sized lobsters are more abundant

3.6 TABLES

***Table 3.1** – Number of licences reporting and the percentage of the total number of licences reporting by LFA or sub unit. NOTE – The difference in total LFA 27 North plus LFA 27 South licences and the total LFA 27 licences is explained by those licences not reporting a port landed or a port landed outside of LFA 27. The difference in total LFA 33 East plus LFA 33 West licences and the total LFA 33 licences is explained by the change in the licence activity between 2004 and 2010, being that the data is based on the 2010 licensing information.*

LFA 27 – 485 Licences

YEAR	MAY		JUN		JULY	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	375	77%	376	78%	367	76%
2005	395	81%	398	82%	402	83%
2006	349	72%	351	72%	348	72%
2007	365	75%	365	75%	366	75%
2008	473	98%	472	97%	470	97%
2009	463	95%	462	95%	456	94%
2010	387	80%	381	79%	371	76%

LFA 27 North – 165 Licences

YEAR	MAY		JUN		JULY	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	145	88%	144	87%	139	84%
2005	140	85%	143	87%	147	89%
2006	128	78%	126	76%	123	75%
2007	129	78%	131	79%	138	84%
2008	158	96%	158	96%	157	95%
2009	158	96%	156	95%	153	93%
2010	143	87%	139	84%	136	82%

LFA 27 South – 320 Licences

YEAR	MAY		JUN		JULY	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	228	71%	230	72%	225	70%
2005	252	79%	254	79%	253	79%
2006	221	69%	224	70%	222	69%
2007	233	73%	232	73%	226	71%
2008	313	98%	313	98%	311	97%
2009	302	94%	300	94%	291	91%
2010	243	76%	241	75%	234	73%

LFA 28 – 15 Licences

YEAR	MAY		JUN		JULY	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	6	40%	5	33%	2	13%
2005	7	47%	6	40%	6	40%
2006	7	47%	7	47%	2	13%
2007	6	40%	5	33%	2	13%
2008	8	53%	8	53%		0%
2009	9	60%	9	60%	1	7%
2010	3	20%	2	13%		0%

Table 3.1 (Cont'd) *– Number of licences reporting and the percentage of the total number of licences reporting by LFA or sub unit.*

LFA 29 – 67 Licences

YEAR	MAY		JUN		JULY	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	47	70%	45	67%	44	66%
2005	53	79%	51	76%	50	75%
2006	56	84%	56	84%	56	84%
2007	47	70%	49	73%		
2008	67	100%	67	100%		
2009	65	97%	64	96%		
2010	62	93%	60	90%		

LFA 30 – 20 Licences

YEAR	MAY		JUN		JULY	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	14	70%	14	70%	14	70%
2005	17	85%	17	85%	17	85%
2006	18	90%	18	90%	18	90%
2007	13	65%	13	65%	12	60%
2008	20	100%	20	100%	20	100%
2009	20	100%	20	100%	20	100%
2010	18	90%	18	90%	18	90%

LFA 31A – 72 Licences

YEAR	APRIL		MAY		JUN	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	50	69%	53	74%	53	74%
2005	62	86%	64	89%	65	90%
2006	60	83%	66	92%	66	92%
2007	58	81%	66	92%	62	86%
2008	71	99%	71	99%	70	97%
2009	71	99%	70	97%	71	99%
2010	69	96%	69	96%	69	96%

LFA 31B – 71 Licences

YEAR	APRIL		MAY		JUN	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	64	90%	63	89%	62	87%
2005	69	97%	68	96%	68	96%
2006	66	93%	65	92%	65	92%
2007	66	93%	67	94%	66	93%
2008	71	100%	71	100%	71	100%
2009	71	100%	71	100%	70	99%
2010	71	100%	71	100%	69	97%

LFA 32 – 161 Licences

YEAR	APRIL		MAY		JUN	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	108	67%	109	68%	107	66%
2005	130	81%	131	81%	123	76%
2006	131	81%	132	82%	131	81%
2007	123	76%	121	75%	123	76%
2008	150	93%	150	93%	150	93%
2009	148	92%	147	91%	147	91%
2010	139	86%	137	85%	135	84%

Table 3.1 (cont'd) *– Number of licences reporting and the percentage of the total number of licences reporting by LFA or sub unit.*

LFA 33 – 705 Licences

YEAR	JAN		FEB		MAR		APR		MAY		NOV		DEC	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	585	83%	547	78%	571	81%	599	85%	611	87%	159	23%	615	87%
2005	612	87%	602	85%	636	90%	639	91%	636	90%	644	91%	650	92%
2006	607	86%	581	82%	594	84%	614	87%	616	87%	616	87%	621	88%
2007	585	83%	556	79%	581	82%	593	84%	595	84%	664	94%	661	94%
2008	643	91%	630	89%	633	90%	652	92%	649	92%	648	92%	646	92%
2009	611	87%	595	84%	642	91%	648	92%	647	92%	414	59%	637	90%
2010	601	85%	579	82%	599	85%	629	89%	616	87%				

LFA 33 East – 263 Licences

YEAR	JAN		FEB		MAR		APR		MAY		NOV		DEC	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	204	78%	208	79%	214	81%	216	82%	218	83%	75	29%	220	84%
2005	218	83%	231	88%	236	90%	233	89%	231	88%	233	89%	237	90%
2006	214	81%	217	83%	214	81%	221	84%	221	84%	232	88%	233	89%
2007	209	79%	202	77%	217	83%	223	85%	225	86%	251	95%	250	95%
2008	240	91%	241	92%	243	92%	250	95%	247	94%	242	92%	241	92%
2009	216	82%	227	86%	243	92%	243	92%	242	92%	152	58%	240	91%
2010	214	81%	211	80%	224	85%	236	90%	230	87%				

LFA 33 West – 442 Licences

YEAR	JAN		FEB		MAR		APR		MAY		NOV		DEC	
	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%	# of licences reporting	%
2004	374	85%	332	75%	350	79%	376	85%	385	87%	81	18%	388	88%
2005	384	87%	361	82%	391	88%	398	90%	399	90%	404	91%	406	92%
2006	386	87%	357	81%	373	84%	386	87%	388	88%	380	86%	384	87%
2007	372	84%	350	79%	360	81%	367	83%	367	83%	410	93%	409	93%
2008	400	90%	386	87%	387	88%	399	90%	399	90%	403	91%	402	91%
2009	392	89%	365	83%	396	90%	402	91%	402	91%	262	59%	397	90%
2010	387	88%	368	83%	375	85%	393	89%	386	87%				

***Table 3.2** – Numbers of Lobster Catch and Settlement Reports with a reported weight, a reported weight and effort (TH) and the percentage of records with effort. NOTE – The difference in total LFA 27 North plus LFA 27 South licences and the total LFA 27 licences is explained by those licences not reporting a port landed or a port landed outside of LFA 27. The difference in total LFA 33 East plus LFA 33 West licences and the total LFA 33 licences is explained by the change in the licence activity between 2004 and 2010, being that the data is based on the 2010 licensing information.*

LFA 27

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	4272	134	3%	9102	310	3%	3387	122	4%
2005	4090	680	17%	9513	1922	20%	4333	1011	23%
2006	4923	2765	56%	7539	4222	56%	3026	1675	55%
2007	5479	3457	63%	8310	5241	63%	2809	1686	60%
2008	5232	5099	97%	9885	9644	98%	4945	4750	96%
2009	5547	5266	95%	9400	8982	96%	3870	3670	95%
2010	4487	4340	97%	8476	8224	97%	3483	3305	95%

LFA 27 North

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	1727	51	3%	3526	108	3%	1224	49	4%
2005	1488	262	18%	3474	683	20%	1537	397	26%
2006	1809	1168	65%	2644	1683	64%	1057	647	61%
2007	1977	1341	68%	3117	2031	65%	1079	656	61%
2008	1768	1707	97%	3283	3172	97%	1638	1577	96%
2009	1915	1791	94%	3208	2981	93%	1288	1204	93%
2010	1709	1657	97%	3136	3103	99%	1259	1219	97%

LFA 27 South

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	2523	83	3%	5538	202	4%	2143	73	3%
2005	2574	409	16%	5988	1239	21%	2771	614	22%
2006	3114	1597	51%	4895	2539	52%	1969	1028	52%
2007	3502	2116	60%	5173	3190	62%	1730	1030	60%
2008	3464	3392	98%	6602	6472	98%	3307	3173	96%
2009	3620	3463	96%	6111	5920	97%	2564	2448	95%
2010	2767	2672	97%	5321	5102	96%	2215	2077	94%

LFA 28

YEAR	MAY			JUNE		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	88	0	0%	78	0	0%
2005	94	5	5%	115	15	13%
2006	120	43	36%	114	43	38%
2007	112	0	0%	86	0	0%
2008	122	87	71%	147	112	76%
2009	117	114	97%	119	119	100%
2010	47	47	100%	38	38	100%

Table 3.2 – (Cont'd.)

LFA 29

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	777	0	0%	987	0	0%	287	0	0%
2005	870	42	5%	1230	73	6%	341	37	11%
2006	993	356	36%	1334	438	33%	359	114	32%
2007	1300	830	64%	1260	715	57%			
2008	1759	1728	98%	1667	1620	97%			
2009	1743	1632	94%	1533	1500	98%			
2010	1531	1485	97%	1399	1350	96%			

LFA 30

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	132	0	0%	349	0	0%	198	0	0%
2005	79	6	8%	434	24	6%	287	10	3%
2006	150	53	35%	407	125	31%	287	89	31%
2007	134	62	46%	324	174	54%	183	100	55%
2008	142	142	100%	473	473	100%	324	306	94%
2009	200	200	100%	473	473	100%	324	324	100%
2010	166	165	99%	429	429	100%	263	263	100%

LFA 31A

YEAR	APR			MAY			JUN		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	35	0	0%	1209	0	0%	1086	0	0%
2005	27	3	11%	1392	157	11%	1504	160	11%
2006	50	44	88%	1644	1298	79%	1438	1107	77%
2007	54	46	85%	1730	1507	87%	1407	1245	88%
2008	63	61	97%	1815	1783	98%	1715	1691	99%
2009	51	49	96%	1926	1926	100%	1577	1555	99%
2010	66	64	97%	1826	1798	98%	1635	1631	100%

LFA 31B

YEAR	APR			MAY			JUN		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	606	0	0%	1803	0	0%	1021	0	0%
2005	628	19	3%	1715	95	6%	1294	93	7%
2006	683	548	80%	1834	1552	85%	1059	909	86%
2007	576	503	87%	1939	1701	88%	1283	1075	84%
2008	665	646	97%	1902	1869	98%	1283	1246	97%
2009	639	638	100%	2011	1955	97%	1295	1249	96%
2010	755	733	97%	1939	1890	97%	1122	1088	97%

LFA 32

YEAR	APR			MAY			JUN		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	877	0	0%	2611	0	0%	1463	0	0%
2005	1005	149	15%	2800	455	16%	1760	323	18%
2006	1217	853	70%	3020	2140	71%	1762	1222	69%
2007	989	690	70%	3209	2341	73%	2130	1512	71%
2008	1412	1366	97%	3533	3365	95%	2181	2128	98%
2009	1234	1190	96%	3744	3662	98%	2129	2094	98%
2010	1381	1352	98%	3296	3243	98%	1731	1665	96%

Table 3.2 – Continued.

LFA 33

YEAR	JAN			FEB			MAR			APR			MAY			NOV			DEC		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	2384	0	0%	315	0	0%	233	0	0%	2056	0	0%	10680	0	0%	50	3	6%	9972	13	0%
2005	2505	15	1%	329	17	5%	553	14	3%	4338	40	1%	10607	121	1%	1242	780	63%	10575	7028	66%
2006	2785	1999	72%	820	588	72%	1618	1086	67%	4465	2936	66%	9761	6563	67%	1792	1446	81%	10850	8777	81%
2007	2894	2366	82%	669	555	83%	713	592	83%	3193	2493	78%	10842	8570	79%	2057	2007	98%	9081	8830	97%
2008	3627	3524	97%	962	934	97%	1662	1597	96%	5838	5458	93%	11994	11149	93%	3020	2903	96%	8292	7884	95%
2009	2779	2628	95%	1013	962	95%	2412	2232	93%	6035	5600	93%	11980	11184	93%	3	3	100%	9142	8784	96%
2010	3305	3148	95%	1160	1075	93%	1387	1342	97%	6535	6188	95%	12351	11736	95%						

LFA 33 East

YEAR	JAN			FEB			MAR			APR			MAY			NOV			DEC		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	395	0	0%	70	0	0%	54	0	0%	806	0	0%	3551	0	0%	15	3	20%	3372	13	0%
2005	380	0	0%	47	0	0%	123	0	0%	1323	0	0%	3518	17	0%	434	235	54%	3587	2114	59%
2006	649	468	72%	151	106	70%	394	272	69%	1840	1170	64%	3676	2341	64%	664	526	79%	3876	3061	79%
2007	651	549	84%	91	79	87%	153	136	89%	1209	952	79%	3914	2979	76%	800	790	99%	3367	3308	98%
2008	739	731	99%	140	127	91%	382	367	96%	2065	1968	95%	4307	4092	95%	1124	1090	97%	3054	2938	96%
2009	524	507	97%	134	117	87%	523	509	97%	1967	1885	96%	4388	4186	95%	1	1	100%	3671	3526	96%
2010	788	758	96%	174	168	97%	508	504	99%	2247	2162	96%	4209	4069	97%						

LFA 33 West

YEAR	JAN			FEB			MAR			APR			MAY			NOV			DEC		
	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%	# recs with weight	# recs with weight & TH	%
2004	1978	0	0%	245	0	0%	179	0	0%	1241	0	0%	7058	0	0%	34	0	0%	6533	0	0%
2005	2104	15	1%	282	17	6%	428	14	3%	2989	40	1%	7060	104	1%	802	543	68%	6953	4900	70%
2006	2136	1531	72%	669	482	72%	1224	814	67%	2625	1766	67%	6085	4222	69%	1125	920	82%	6957	5716	82%
2007	2243	1817	81%	578	476	82%	560	456	81%	1984	1541	78%	6928	5591	81%	1253	1213	97%	5699	5507	97%
2008	2888	2793	97%	822	807	98%	1269	1219	96%	3752	3469	92%	7657	7027	92%	1885	1802	96%	5221	4929	94%
2009	2255	2121	94%	879	845	96%	1889	1723	91%	4062	3709	91%	7566	6972	92%	2	2	100%	5471	5258	96%
2010	2517	2390	95%	986	907	92%	879	838	95%	4288	4026	94%	8142	7667	94%						

Table 3.3 – Numbers of Lobster Catch and Settlement Reports with a reported weight, a reported weight and valid grid and the percentage of records with valid grid. NOTE – The difference in total LFA 27 North plus LFA 27 South licences and the total LFA 27 licences is explained by those licences not reporting a port landed or a port landed outside of LFA 27. The difference in total LFA 33 East plus LFA 33 West licences and the total LFA 33 licences is explained by the change in the licence activity between 2004 and 2010, being that the data is based on the 2010 licensing information.

LFA 27

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	4272	173	4%	9102	466	5%	3387	176	5%
2005	4090	698	17%	9513	1966	21%	4333	1039	24%
2006	4923	2557	52%	7539	4046	54%	3026	1618	53%
2007	5479	3341	61%	8310	5129	62%	2809	1623	58%
2008	5232	5029	96%	9885	9415	95%	4945	4700	95%
2009	5547	5124	92%	9400	8680	92%	3870	3523	91%
2010	4487	4146	92%	8476	7666	90%	3483	3182	91%

LFA 27 North

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	1727	38	2%	3526	108	3%	1224	49	4%
2005	1488	230	15%	3474	645	19%	1537	369	24%
2006	1809	1053	58%	2644	1573	59%	1057	611	58%
2007	1977	1341	68%	3117	2076	67%	1079	648	60%
2008	1768	1698	96%	3283	3142	96%	1638	1558	95%
2009	1915	1788	93%	3208	2979	93%	1288	1188	92%
2010	1709	1590	93%	3136	2931	93%	1259	1164	92%

LFA 27 South

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	2523	135	5%	5538	358	6%	2143	127	6%
2005	2574	468	18%	5988	1321	22%	2771	670	24%
2006	3114	1504	48%	4895	2473	51%	1969	1007	51%
2007	3502	2000	57%	5173	3033	59%	1730	975	56%
2008	3464	3331	96%	6602	6273	95%	3307	3142	95%
2009	3620	3336	92%	6111	5637	92%	2564	2324	91%
2010	2767	2502	90%	5321	4629	87%	2215	1974	89%

LFA 28

MAY			JUNE		
# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
88	0	0%	78	0	0%
94	0	0%	115	0	0%
120	0	0%	114	0	0%
112	0	0%	86	0	0%
122	87	71%	147	112	76%
117	103	88%	119	105	88%
47	47	100%	38	38	100%

Table 3.3 – Continued.

LFA 29

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	777	0	0%	987	0	0%	287	0	0%
2005	870	34	4%	1230	43	3%	341	38	11%
2006	993	272	27%	1334	310	23%	359	83	23%
2007	1300	664	51%	1260	613	49%			
2008	1759	1650	94%	1667	1538	92%			
2009	1743	1552	89%	1533	1289	84%			
2010	1531	1446	94%	1399	1284	92%			

LFA 30

YEAR	MAY			JUNE			JULY		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	132	0	0%	349	0	0%	198	0	0%
2005	79	0	0%	434	0	0%	287	0	0%
2006	150	47	31%	407	125	31%	287	89	31%
2007	134	62	46%	324	175	54%	183	107	58%
2008	142	142	100%	473	473	100%	324	324	100%
2009	200	200	100%	473	473	100%	324	324	100%
2010	166	166	100%	429	429	100%	263	247	94%

LFA 31A

YEAR	APR			MAY			JUN		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	35	0	0%	1209	0	0%	1086	0	0%
2005	27	2	7%	1392	106	8%	1504	68	5%
2006	50	36	72%	1644	1058	64%	1438	931	65%
2007	54	39	72%	1730	1202	69%	1407	1053	75%
2008	63	59	94%	1815	1763	97%	1715	1666	97%
2009	51	48	94%	1926	1765	92%	1577	1404	89%
2010	66	60	91%	1826	1638	90%	1635	1444	88%

LFA 31B

YEAR	APR			MAY			JUN		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	606	0	0%	1803	0	0%	1021	0	0%
2005	628	9	1%	1715	69	4%	1294	73	6%
2006	683	548	80%	1834	1550	85%	1059	831	78%
2007	576	484	84%	1939	1606	83%	1283	1067	83%
2008	665	665	100%	1902	1901	100%	1283	1229	96%
2009	639	618	97%	2011	1841	92%	1295	1203	93%
2010	755	694	92%	1939	1784	92%	1122	1039	93%

LFA 32

YEAR	APR			MAY			JUN		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	877	0	0%	2611	0	0%	1463	0	0%
2005	1005	89	9%	2800	364	13%	1760	264	15%
2006	1217	733	60%	3020	1888	63%	1762	1093	62%
2007	989	640	65%	3209	2151	67%	2130	1423	67%
2008	1412	1296	92%	3533	3239	92%	2181	1976	91%
2009	1234	1067	86%	3744	3196	85%	2129	1857	87%
2010	1374	1081	79%	3284	2457	75%	1731	1330	77%

Table 3.3 *– Continued.*

LFA 33

YEAR	JAN			FEB			MAR			APR			MAY			NOV			DEC		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	2384	0	0%	315	0	0%	233	0	0%	2056	0	0%	10680	0	0%	50	0	0%	9972	0	0%
2005	2505	15	1%	329	17	5%	553	14	3%	4338	25	1%	10607	79	1%	1242	764	62%	10575	7040	67%
2006	2785	2081	75%	820	614	75%	1618	1209	75%	4465	3205	72%	9761	6982	72%	1792	1445	81%	10850	9038	83%
2007	2894	2457	85%	669	603	90%	713	669	94%	3193	2727	85%	10842	9131	84%	2057	2019	98%	9081	8924	98%
2008	3627	3590	99%	962	955	99%	1662	1635	98%	5838	5681	97%	11994	11674	97%	3020	2934	97%	8292	7926	96%
2009	2779	2662	96%	1013	979	97%	2412	2271	94%	6035	5719	95%	11980	11264	94%	3	2	67%	9142	8557	94%
2010	3305	3045	92%	1160	1053	91%	1387	1291	93%	6535	6006	92%	12351	11515	93%						

LFA 33 East

YEAR	JAN			FEB			MAR			APR			MAY			NOV			DEC		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	395	0	0%	70	0	0%	54	0	0%	806	0	0%	3551	0	0%	15	0	0%	3372	0	0%
2005	380	0	0%	47	0	0%	123	0	0%	1323	0	0%	3518	0	0%	434	231	53%	3587	2172	61%
2006	649	460	71%	151	113	75%	394	278	71%	1840	1299	71%	3676	2580	70%	664	503	76%	3876	3185	82%
2007	651	564	87%	91	80	88%	153	141	92%	1209	980	81%	3914	3193	82%	800	789	99%	3367	3322	99%
2008	739	737	100%	140	139	99%	382	370	97%	2065	2035	99%	4307	4193	97%	1124	1097	98%	3054	2940	96%
2009	524	500	95%	134	123	92%	523	505	97%	1967	1883	96%	4388	4097	93%	1	1	100%	3671	3514	96%
2010	788	759	96%	174	159	91%	508	470	93%	2247	2121	94%	4209	4017	95%						

LFA 33 West

YEAR	JAN			FEB			MAR			APR			MAY			NOV			DEC		
	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%	# recs with weight	# recs with weight & grid	%
2004	1978	0	0%	245	0	0%	179	0	0%	1241	0	0%	7058	0	0%	34	0	0%	6533	0	0%
2005	2104	15	1%	282	17	6%	428	14	3%	2989	25	1%	7060	79	1%	802	531	66%	6953	4854	70%
2006	2136	1621	76%	669	501	75%	1224	931	76%	2625	1906	73%	6085	4402	72%	1125	942	84%	6957	5853	84%
2007	2243	1893	84%	578	523	90%	560	528	94%	1984	1747	88%	6928	5938	86%	1253	1226	98%	5699	5587	98%
2008	2888	2853	99%	822	816	99%	1269	1254	99%	3752	3625	97%	7657	7451	97%	1885	1826	97%	5221	4969	95%
2009	2255	2162	96%	879	856	97%	1889	1766	93%	4062	3830	94%	7566	7141	94%	2	1	50%	5471	5043	92%
2010	2517	2286	91%	986	894	91%	879	821	93%	4288	3885	91%	8142	7498	92%						

***Table 3.4** – Total of MARFIS logbook estimates, slip weights and the percent difference, annually for LFA 27-32 and seasonally for LFA 33.*

YEAR	27			28			29			30			31A			31B			32		
	LOG	SLIP	% DIFF	LOG	SLIP	% DIFF	LOG	SLIP	% DIFF	LOG	SLIP	% DIFF	LOG	SLIP	% DIFF	LOG	SLIP	% DIFF	LOG	SLIP	% DIFF
2002	1,196	1,293	8%	7	8	13%	56	57	2%	77	79	3%	102	103	1%	211	210	0%	352	358	2%
2003	1,395	1,540	9%	12	13	8%	125	125	0%	77	73	-5%	154	152	-1%	281	279	-1%	380	389	2%
2004	1,649	1,735	5%	8	8	0%	188	190	1%	81	84	4%	216	213	-1%	295	305	3%	283	289	2%
2005	1,775	1,919	8%	9	9	0%	402	402	0%	111	112	1%	424	426	0%	506	498	-2%	377	403	6%
2006	1,691	1,848	8%	10	11	9%	655	658	0%	185	187	1%	661	672	2%	830	825	-1%	575	602	4%
2007	1,803	1,914	6%	9	9	0%	763	792	4%	215	216	0%	799	827	3%	1,022	1,061	4%	619	632	2%
2008	2,547	2,711	6%	12	13	8%	1,031	1,076	4%	400	413	3%	927	962	4%	1,006	1,031	2%	688	704	2%
2009	1,998	2,072	4%	13	14	7%	1,023	1,085	6%	461	452	-2%	952	956	0%	1,219	1,270	4%	777	829	6%

SEASON	33		
	LOG	SLIP	% DIFF
2002-2003	2,345	2,320	-1%
2003-2004	2,006	1,955	-3%
2004-2005	2,523	2,518	0%
2005-2006	2,595	2,556	-2%
2006-2007	3,037	3,033	0%
2007-2008	2,575	2,599	1%
2008-2009	3,479	3,402	-2%
2009-2010	3,530	3,387	-4%

***Table 3.5** – Number of voluntary logbook participants, 1981 to 2009, LFA 27 to 32.*

SEASON	LFA 27 NORTH	LFA 27 SOUTH	LFA 28	LFA 29	LFA 30	LFA 31	LFA 32	Grand Total
1981	1							1
1982	1							1
1983	1							1
1984	1							1
1985	2	1			2	1	1	7
1986	3	2		3	2	7	3	20
1987	3	2		3	2	10	5	25
1988	5	2		4	2	11	5	29
1989	5	4		5	2	12	3	31
1990	5	4	1	4	2	15	5	36
1991	5	3	1	5	2	15	6	37
1992	10	17	1	8	7	12	6	61
1993	25	19	2	9	6	16	11	88
1994	26	22	2	11	6	17	19	103
1995	29	24	1	8	6	13	17	98
1996	27	23		7	7	13	15	92
1997	25	23		6	7	13	11	85
1998	24	22		5	4	9	11	75
1999	20	17		5	4	7	7	60
2000	21	15		5	4	5	7	57
2001	19	16		4	4	6	8	57
2002	18	16		3	4	11	7	59
2003	18	15		2	4	9	8	56
2004	16	12		1	3	9	8	49
2005	15	9		1	2	9	8	44
2006	13	9		1	2	6	4	35
2007	13	8		1	2	3	1	28
2008	9	8		1	2	1		21
2009	7	7		1	2			17
	367	300	8	103	90	230	176	**1274**

***Table 3.6** – Number of voluntary logbook participants by season, LFA 33.*

SEASON	LFA 33 EAST	LFA 33 WEST	Grand Total
1984-1985	5	3	8
1985-1986	5	5	10
1986-1987	6	6	12
1987-1988	7	7	14
1988-1989	8	5	13
1989-1990	6	8	14
1990-1991	5	7	12
1991-1992	8	7	15
1992-1993	8	6	14
1993-1994	9	11	20
1994-1995	10	9	19
1995-1996	8	12	20
1996-1997	7	11	18
1997-1998	12	13	25
1998-1999	5	14	19
1999-2000	6	11	17
2000-2001	10	17	27
2001-2002	12	15	27
2002-2003	8	16	24
2003-2004	8	15	23
2004-2005	8	13	21
2005-2006	8	12	20
2006-2007	7	13	20
Grand Total	176	236	**412**

***Table 3.7** – Numbers of at-sea samples stored in the LOBBIO database for LFAs 27-33.*

LFA	# SAMPLES	YEARS
27	88	1977-1999
29	23	1979-1998
30	135	1947-1998
33	13	1998-2000
Grand Total	**259**	

***Table 3.8** – Number of at-sea samples store in the CRIS database for LFAs 27-33.*

LFA	# SAMPLES	YEARS
27	190	1985-2009
28	18	1993-2001
29	27	1990-2008
30	73	1990-2008
31	157	1982-2010
32	66	1981-2010
33	36	2001-2009
Grand Total	**567**	

***Table 3.9** – Number of SARA samples completed from the lobster fishery, 2008-2010, LFA 27-33.*

LFA	2008	2009	2010	TOTAL
27	0	40	0	40
30	0	3	0	3
31A	0	15	0	15
31B	0	23	0	23
32	0	12	0	12
33	3	172	1	176
TOTAL	3	265	1	**269**

***Table 3.10** - Numbers of port samples by LFA and year.*

	LFA							
YEAR	27	28	29	30	31	32	33	TOTAL
1946							1	1
1947							1	1
1949							1	1
1977					1	1		2
1978	4							4
1980	46			10	5			61
1981	20			5		1		26
1982	37		7	2	12			58
1984	20				4	2	11	37
1985	45		2	1	4	2	8	62
1986					4	3	7	14
1987	4				4	2	17	27
1988					4	2	13	19
1989	34		7		4	2	11	58
1990	20		3		4	2	7	36
1991	9		3		3	2	8	25
1992			1		4	2	9	16
1993	2		5	2	4	2	8	23
1994	6	2	10	2	4	2	8	34
1995	4	1	4	3		1	8	21
1996	56		6	2	4	2	8	78
1997	32		4	1			10	47
1998	25	1	64	10	6	2	15	123
1999	26		6		4	4	10	50
2000	24		18		9	7	11	69
2001	22		6		6	4	5	43
2002	10		3		7	4		24
2003	10		4		8	4		26
2004	6		4		12	3		25
2005	4		2		5			11
2006					9	1	6	16
2007	4		1		4	1	3	13
2008	9		1				7	17
2009	9		3		1		15	28
2010							5	5
TOTAL	488	4	164	38	136	58	213	1101

***Table 3.11** – Number of participants in the FSRS recruitment trap project, 1999-2009, LFA 27-33.*

YEAR	LFA 27	LFA 28	LFA 29	LFA 30	LFA 31A	LFA 31B	LFA 32	LFA 33	SEASON	TOTAL
1999	21	0	1	0	4	4	14	23	1998-1999	67
2000	23	0	4	2	4	8	11	31	1999-2000	83
2001	24	2	4	2	5	8	11	30	2000-2001	86
2002	23	2	4	2	6	12	13	32	2001-2002	94
2003	28	2	4	3	6	12	13	42	2002-2003	110
2004	29	2	4	2	6	9	14	46	2003-2004	112
2005	28	2	4	4	6	12	18	52	2004-2005	126
2006	30	1	6	7	7	12	18	51	2005-2006	132
2007	30	1	8	7	8	12	18	47	2006-2007	131
2008	28	1	8	6	6	11	17	39	2007-2008	116
2009	30	1	7	7	8	11	17	41	2008-2009	122

3.7 FIGURES

Figure 3.1 *– Nova Scotia counties.*

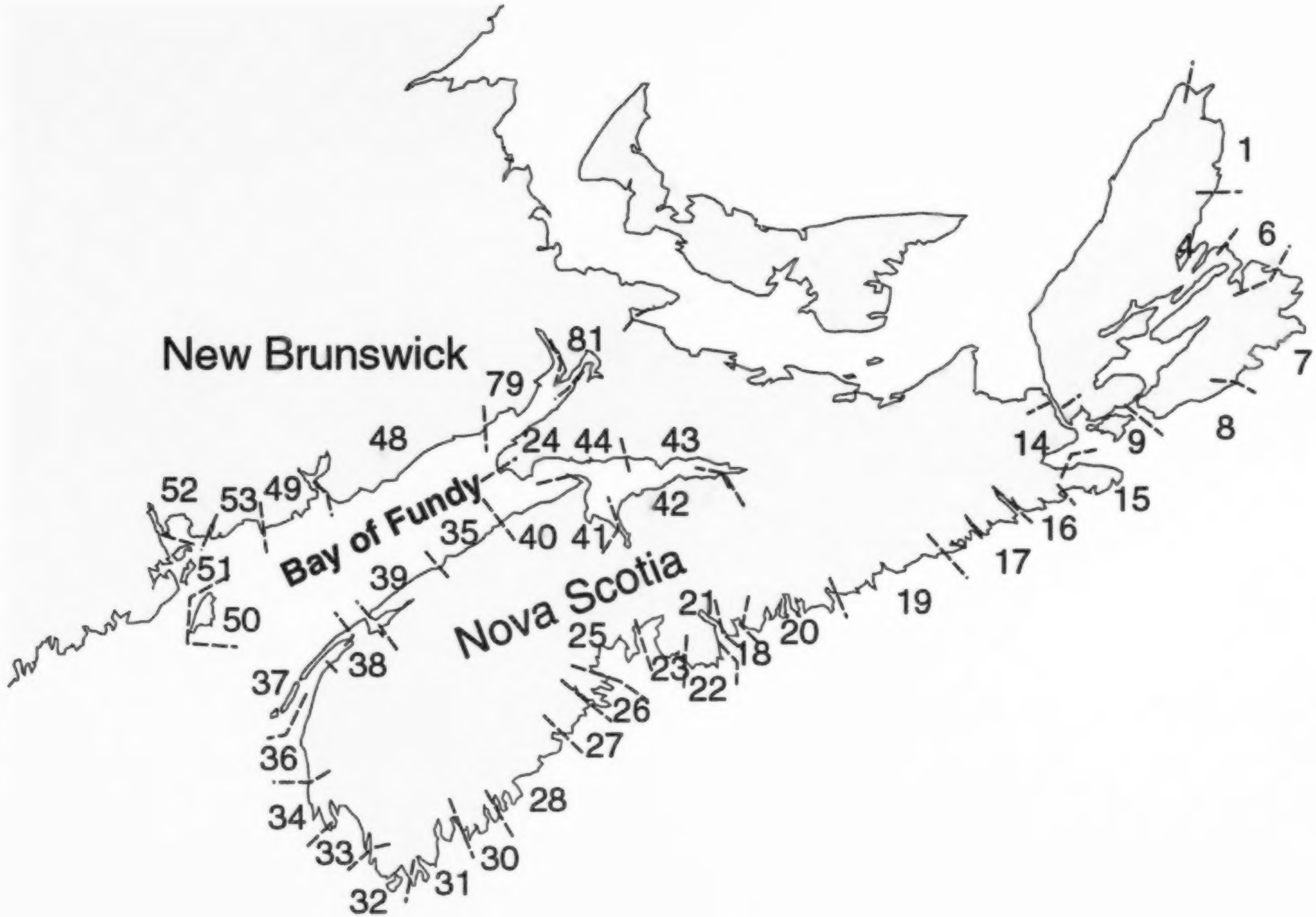


***Figure 3.2** – Statistical district boundaries.*

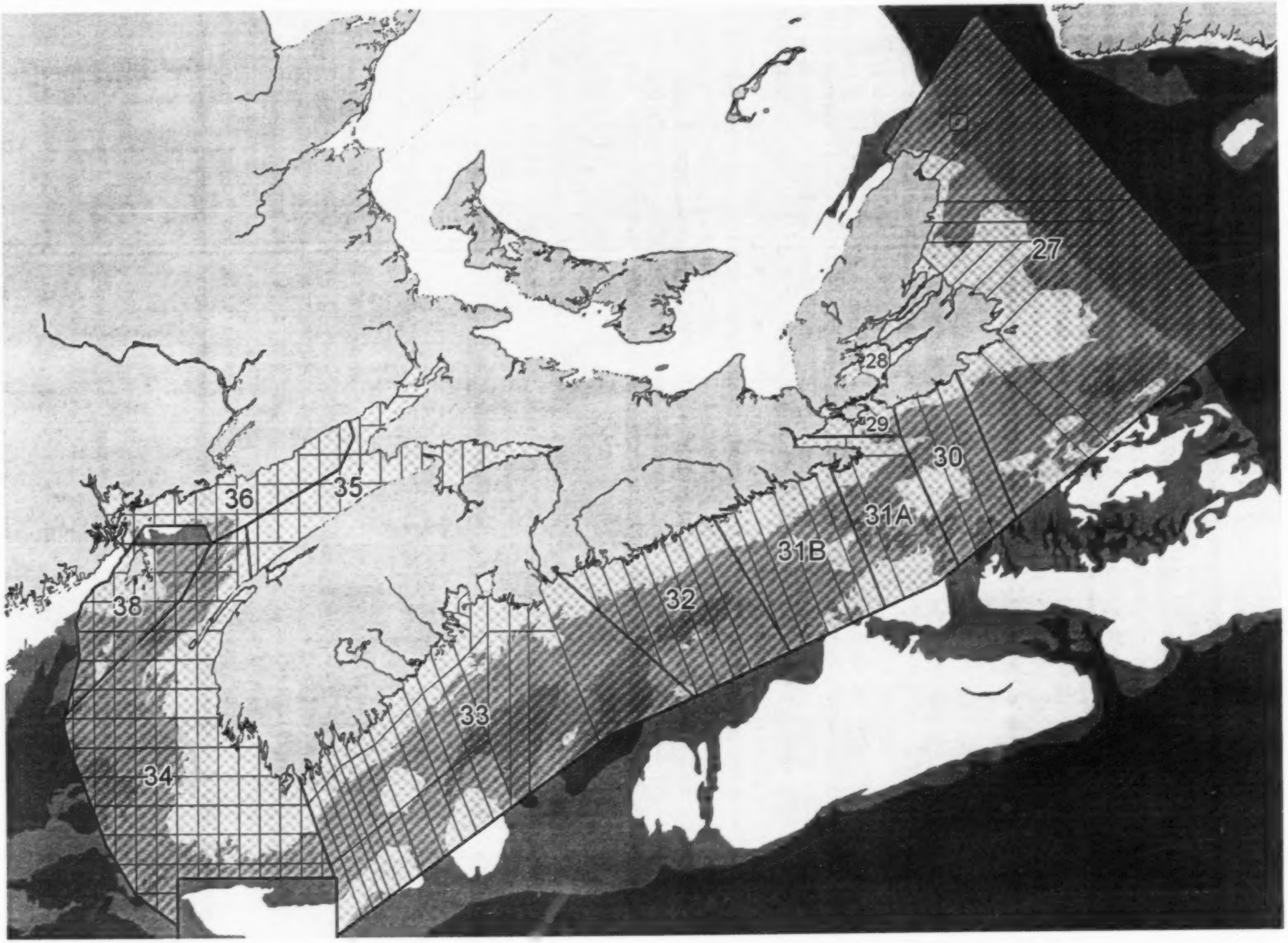


Figure 3.3 – Logbook reporting grid, LFA 27-38.

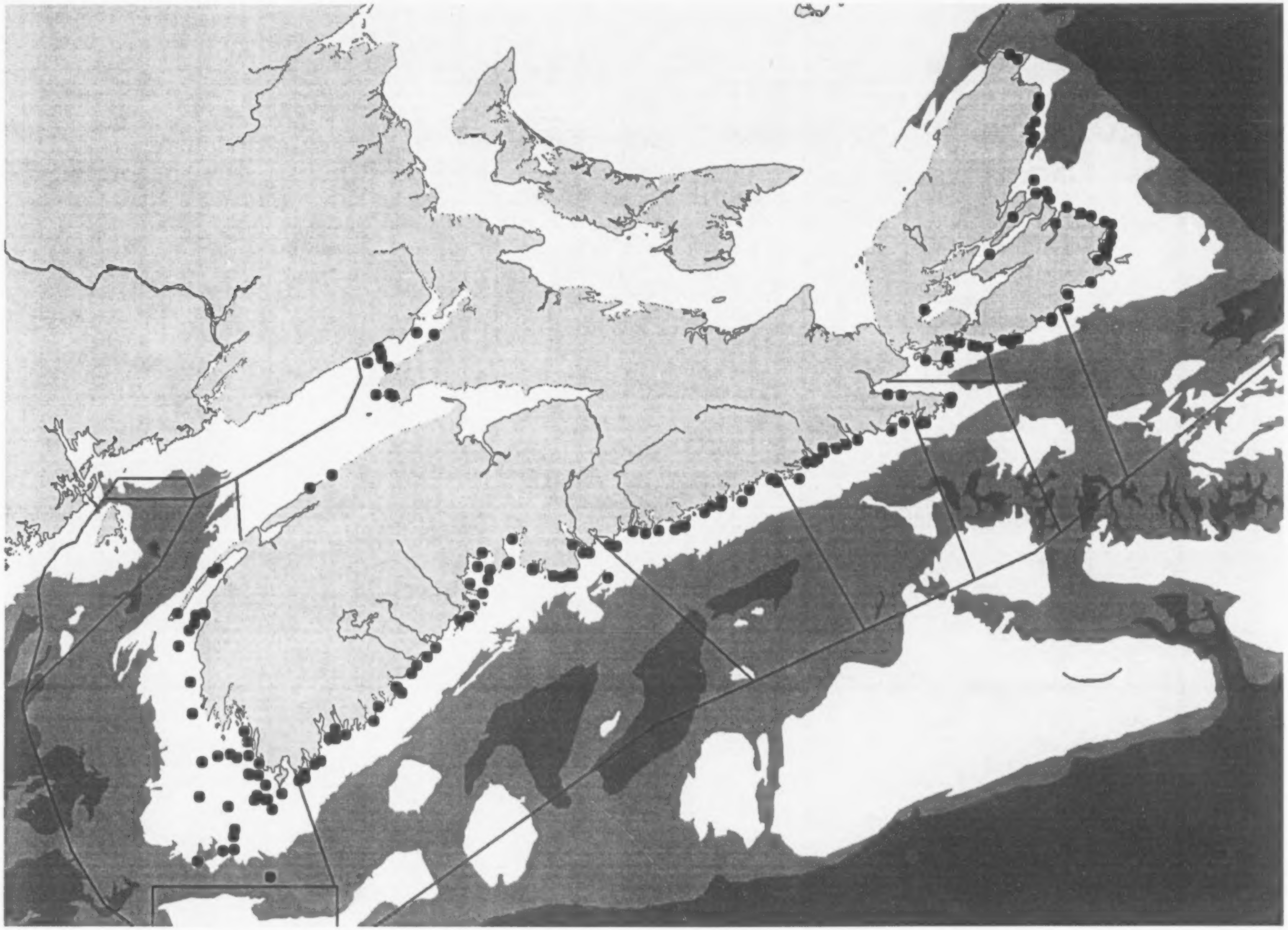


Figure 3.4 – FSRS recruitment trap distribution, spring 2009.

4. INDICATORS OF ABUNDANCE OF LEGAL SIZES FROM LANDINGS AND COMMERCIAL LOGS

4.1 INTRODUCTION

This sections deals with abundance of lobsters of commercial size (=legal size) based on data from commercial traps. Data on the abundance of legal sized lobsters for LFAs 27-33 all originates from traps fished during the open fishing seasons and includes basic data such as landings as well as commercial catch rate. Data from FSRS traps (also fished during the open fishing seasons) are analyzed in section 5.

Annual mean commercial catch rates from a fishery are often used as indicators of population abundance with changes in the annual values expected to reflect similar changes in the population being fished (Quinn and Deriso 1999). We consider catch rate as an index of abundance, but make no assumption about the form of the relationship between catch rate and abundance.

Catch rate is affected by lobster catchability. The catch rate may be linearly related with abundance over some abundance ranges but the relationship is likely non-linear at some high abundance because of trap saturation. Nonlinear relationships in CPUE and abundance are typical of most fisheries, and have been described by the terms hyperdepletion and hyperstability (Hilborn and Walters 1992). Hyperdepletion occurs when CPUE falls much more rapidly than abundance, while hyperstability occurs when CPUE remains constant in the face of declining abundances. Caution is necessary in interpretation of CPUE values and efforts should be made to determine the relationship between CPUE and abundance.

Catch rates are affected by factors other than abundance such as time period and area fished. For this reason, statistical models are fit to these data to account for any extra variation that is independent of population change so that any changes believed to be related to population change can be detected.

In this section we document changes in commercial landings and commercial catch rates from logs maintained by fishermen. In Section 2 we show the results of a cluster analysis of landings trends which indicates LFAs can be grouped as follows (LFA 27, LFA 29-32 and LFA 33). LFA 28 could be grouped either with LFA 29-32 as has been done in the past, or with LFA 27, with which it appears to share greater affinity.

4.2 LANDINGS

Landing levels are a function of abundance, level of fishing effort (trap hauls and Soak Over Days (SOD), timing of effort, fishing strategy, catchability (environmental, gear efficiency, density, and lobster movements), and the distribution of animals and effort. Changes in any of these can affect landing levels. Thus, changes in landings are not a direct reflection of changes in abundance.

Major changes in effective effort during the 1980s and 90s that were brought on by changes in vessels, traps and ship board electronics (i.e. sounders, radar, Loran, GPS, mapping) make comparison with older historical levels questionable. However the long time series available can give indications of general trends and patterns.

4.2.1 Methods

Landings data obtained as described in data inputs (section 3).

Historical landings from 1892-1946 were recorded by county which do not always correspond with LFA or Statistical Districts. The 1892-2010 data are presented for LFA 27 (Victoria/ Cape Breton County), LFA 29-31 (Richmond/ Guysborough county) and LFA 32-33 (Halifax/ Lunenburg/ Queens/ Shelburne County).

Landings for 1947-2010 are presented by LFA.

To classify periods of high and low landings, the landings were divided into quartiles. Values that were less than the 25th percentile of the time series were classified as "negative", values between the 25th and 75th percentile were classified as "neutral", and values that were greater than the 75th percentile were classified as "positive".

Three time periods were looked at: Historical data: 1892-2010; 1947-2010 and 1970-2010. The latter time period was chosen to reflect the more recent fishery following introduction of limited entry and trap limits in 1968.

4.2.2 Results and Discussion

Historical Landings

Commercial lobster fishing began in the mid-1800s and annual lobster landings were first recorded in 1892. Canadian landings declined sharply during the 1890s and continued into the early 1920s (Fig. 4.1, Table 4.1). During this phase the fishery was fishing down the accumulated biomass of the previously unfished population. Concerns were raised throughout the Maritimes as early as 1872, when a decline in the average size in the catch was first observed in catches (Venning 1873; Rathbun 1884; Herrick 1897). Over the next 50 years, numerous Government Commissions reviewed the decline and recommended changes in regulations in an attempt to stop further declines (Prince 1899; Wakeham 1909; Knight 1917; MacLean Commission 1928). The landings remained low during the 1930s and early 1940s. Landings rose following WW II and peaking in the mid 1950s then declining throughout the 1960s and 70s. Landings increased throughout the 1980s as part of a western Atlantic wide pattern that saw landings increase over the entire lobster's range.

LFA 27-33

While the overall pattern seen in Canadian landings holds for most regions differences are seen in LFA 27-33 (Fig. 4.2), LFA 27 (Fig. 4.3a) appears to be an exception in that an initial period of high landings followed by a decline is not evident in the data. Landings remained relatively constant through the 1892-1965 period. A decline in the 1970s is evident but less pronounced than in many other areas. Landings then rose rapidly to unprecedented levels during the 1980s and peaked in 1990 followed by a similarly sharp decline before levelling out in 1997. Landings have increased since 2000, with 2009 landings at 56% of the peak of 1990 and 2 times the long term mean 1892-1980.

LFA 28-31 (Fig. 4.3b) exhibited the large decline during the 1890s and early 1900s and was followed by smaller peaks in the early 1930s and mid 1950s. An all time low occurred in the late 1970s. As with LFA 27 landings increased during the 1980s and peaked in 1990, though the

increase was much smaller than observed in LFA 27. Landings rose sharply between 2004 and 2009, with 2009 landings 4.5 times those of 2004 and almost matching the all time highs of 1895.

LFA 32-33 (Fig. 4.3c) exhibited the large decline during the 1890s and early 1900s and was followed by low landings through the 1930s and 1940s. A small increase is evident in the early 1950s but by the 1960s is in decline reaching all time lows in the late 1970s. As observed in other lobster areas landings increased during the 1980s and in LFA 32-33 peaked in 1987. Though landings decline in the early 1990s they remained above levels observed since 1920s and since 2004 have increased. The 2009 landings are at 1.4x the peak of 1987 and 16x the record low of 1978, though still below the all time highs of the 1890s.

Landings 1947-2010

Fig. 4.4 and 4.5 show the landing trends in each LFA between 1947-2010 (2010 landings are preliminary values) and the mean landing levels over the last 10, 25 and 50 years. Tables 4.2 and 4.3 clearly show that in all areas the lowest landings of the time series occurred during the 1970s and with the exception of LFA 27 the highest landings occurred during the last 5 years. See section 2 for a cluster analysis of landings since 1947.

The recent increases in landings are believed to reflect increased abundance, as they are in many cases extremely large and there has been no evidence of a corresponding change in fishing effort prior to the increase. Fishing effort has however responded to the increased landings and with the new revenue fishermen have invested in new vessels and traps.

Peaks and troughs have been observed in many of the regions in the past with both rapid increase and rapid declines in landings. The specific factors controlling abundance and subsequent landings have not been determined.

4.3 CATCH RATE FROM COMMERCIAL LOGS

Commercial logs have been mandatory since 2004-05 however there was a phase in period in some LFAs with the older Self Reporting landings forms submitted and in the initial years records were often incomplete. Return rates and completed information have improved and depending upon the LFA has been good since 2006 or 2007 (see section 3). As a result the time period presently available for analysis is only 3 years and not enough for detailed analysis.

The data available has been used to calculate an overall seasonal CPUE to allow comparison with other data sources. In future assessments the logbook results could be standardized as was done in the 2006 LFA 34 assessment, which began using logs in 1998.

4.3.1 Methods – Commercial Logs

Landings and effort data from the commercial log records as described in 3.1 and are used to obtain a total season CPUE.

Data Included

The data were cleaned by first removing incomplete records. Next records with values outside specific ranges were removed to deal with with errors in reporting or entry. The criteria used are listed below for LFA 27, LFA 28-32 and LFA 33.

LFA 27
INCLUSIONS:
LFA is 27
date fished is within the season
sum of weight a, b and c is not zero
sum of trap hauls a, b and c not zero
grid number a, b and c and community code is not null
licences greater than or equal to 5 days fished in a season
total daily weight for a licence greater than or equal to 10lbs
total daily trap hauls for a licence is greater than or equal to 10
total daily trap hauls for a licence is less than or equal to than 2 times the trap limit plus 10%
days fished when a licence holder reports landings in both LFA 27 sub units (Fig. 4.6)

In LFA 27 no data meets these criteria for 2002 and 2003 due to trap hauls being null

TRAP LIMITS: 275 (max 605)
SEASON: May 10 to July 15

LFA 28 to 32
INCLUSIONS:
LFA is 28,29,30,31A, 31B or 32 depending on area being analyzed
date fished within the season for that LFA
licences with greater than or equal to 5 days fished in a season
total daily weight for a licence not zero and >= 10
total daily trap hauls for a licence not zero and between 10 and 550

In LFAs 28-32, no data meets the criteria for 2002 to 2004 due to trap hauls being null

No criteria for grid number or port were included in the data selection since CPUE was calculated by LFA only.

TRAP LIMITS: LFA 28-32: 250 (max 550)
SEASONS:

LFA	START	END	YEARS
LFA 28	MAY 1	JULY 9	2005 to 2010
LFA 29	MAY 10	JULY 10	2005 to 2006
	MAY 1	JUNE 30	2007 to 2010
LFA 30	MAY 20	JUL 20	2005 to 2010
LFA 31A	APRIL 30	JUNE 30	2005 to 2010
LFA 31B	APRIL 20	JUNE 20	2005 to 2006 and 2008 to 2010
	APRIL 22	JUNE 22	2007
LFA 32	APRIL 20	JUNE 20	2005 to 2006 and 2008 to 2010
	APRIL 22	JUNE 22	2007
	APRIL 22	JUNE 22	2007

LFA 33

INCLUSIONS:

LFA is 33

date fished is within the season

sum of weight of Grid a, b and c is not zero

sum of trap hauls of Grid a, b and c not zero

grid number a, b and c and community code is not null

licences greater than or equal to 5 days fished in a season

total daily weight for a licence greater than or equal to 10lbs

total daily trap hauls for a licence is greater than or equal to 10

total daily trap hauls for a licence is less than or equal to than 2 times the trap limit plus 10%

days fished when a licence holder reports landings in both LFA 33 sub units (4.3.2)

In LFA 33 no data meets these criteria for 2002-03 and 2003-04 due to trap hauls being null

TRAP LIMITS: 250 (max 550)

SEASONS:

SEASON	START	END
2004-05	NOV 30	JUNE 4
2005-06	NOV 29	MAY 31
2006-07	NOV 28	MAY 31
2007-08	NOV 27	MAY 31
2008-09	NOV 25	MAY 31
2009-10	NOV 24	MAY 31

CPUE Calculations

LFA 27

Average CPUE: the average of all CPUEs calculated for each record. A record represents each day fished per licence. This is then weighted by the number of records in each area A, B and C to get one overall CPUE for the LFA subunit.

CPUE by totals: the total weight / total trap hauls. This is then weighted by the number of records in each area A, B and C to get one overall CPUE for the LFA subunit.

LFA 28-32

Average CPUE: the average of all CPUEs calculated for each record. A record represents each day fished per licence.

CPUE by totals: the total weight / total trap hauls.

LFA 33

Average CPUE: the average of all CPUEs calculated for each record. A record represents each day fished per licence. This is then weighted by the number of records in each area A, B and C to get one overall CPUE for the LFA subunit.

CPUE by totals: the total weight / total trap hauls. This is then weighted by the number of records in each area A, B and C to get one overall CPUE for the LFA subunit.

4.3.2 Results and Discussion – Commercial Logs

The return rates of the mandatory logbooks have improved in recent years generally being in the 90-100% range (Table 3.1-3.3). The records useable for estimating CPUE range from 85-100% depending upon the LFA with LFA 27 at 84-85%, LFA 29 at 95-96%, LFA 30-32 at 97-100% and LFA 33 at 85-86%.

Catch rate (CPUE) calculated from the logbook data and expressed in kg per trap haul are presented in Table 4.4 (LFA 27) Table 4.5 (LFA 28-32) Table 4.6 (LFA 33) and Fig. 4.8 (LFA 27-32) and Fig. 4.9 (LFA 33).

The short time series makes discussion of trends or levels very preliminary but as the time series lengthens, their value will increase. In future assessments the data will be available for catch rate modelling.

Overall observation is that over the period of time the data is available the catch rate is relatively constant in LFAs 27-33, though increased catch rate is observed in LFA 30 between 2007 and 2009, in LFA 31a between 2006 and 2009 and to a lesser extent in LFA 31b. All of these also show a small downturn in 2010.

Difficulties still exist in the log data with invalid grid numbers, and unrealistic catch and effort levels in some records. It is unclear if these errors are due to incorrect recording, misinterpretation at time of entry or simple data entry errors. The numbers of such errors is however small and appear to have decreased in recent years but further effort is suggested to improve the data set to allow for more detailed modelling in the future.

4.4 CATCH RATE FROM VOLUNTARY LOGS

Voluntary logs began in the mid 1980s to provide information on catch rates as the self-reporting logs at the time did not include it. There was an initial expansion of the number of logs recorded that peaked in the mid to late 1990s then declined (Table 3.5 and 3.6). Two areas, LFA 27 and 33 maintained the numbers into recent years and these provide a means to compare the voluntary log catch rates with those of the mandatory logs which began in 2006.

4.4.1 Methods – Voluntary Logs

Landings and effort data from the voluntary log records were obtained as described in section 3.1.

Due to of the declining numbers of logs in most LFAs it is not possible to compare the results with the mandatory log records so only LFA 27 and 33 were looked at. The logs from other LFAs could be of use in a full assessment to look at historical trends.

Only logs which met the following criteria were used:

- Class A licence
- Fished at least 4 consecutive seasons
- In LFA 33 fished both fall and spring and in LFA 27 fished all months of the season.

CPUE was calculated by Statistical District by dividing reported landings by reported effort. The CPUE for LFA 27 North and South, and LFA 33 West were calculated using a weighted mean (based on landings) of the CPUE from each SD. CPUE was not calculated for LFA 33 East because too few SD were covered by the voluntary logs.

4.4.2 Results and Discussion – Voluntary Logs

The CPUE by Statistical District for LFA 27 are given in Table 4.7 and Fig. 4.10 and show different levels between the areas but over most of the time series a similar trend in all areas with CPUE declining in the early 1990s and slowly increasing since the late 1990s.

Fig. 4.11 illustrates that voluntary log CPUE had the same overall level and trends are as the CPUE from mandatory logs when calculated in a similar manner. This is encouraging as it may provide a method of extending the time series of CPUEs further back in time by combining the Mandatory and voluntary log time series.

The data from LFA 33 is presented as LFA 33 East and West (Table 4.7 and Fig. 4.12). The number of logs in the east was lower and did not cover all Statistical Districts so and overall weighted CPUE was not possible. LFA 33 West shows wider variations between areas with the more eastern Statistical Districts having lower CPUE levels.

Only three years of data is available at this time to compare with the mandatory logs (Fig. 4.13) but as with LFA 27 the levels are comparable between the two data sets.

4.5 SUMMARY

4.5.1 Landings

Landing levels are a function of abundance and a wide range of other factors (e.g. number of trap hauls, SOD, fishing strategy, catchability (environmental, gear efficiency), density, and lobster movement. Changes in any of these can affect landing levels and landings are not a direct reflection of changes in abundance. In addition there is some uncertainty regarding how well recorded landings reflect true landings, particularly in the early days of the fishery. In spite of these caveats, it is thought that landings are indicative of general trends and patterns of abundance.

Historical landings (pre-1947) for LFAs 27-33 show some large changes associated with the early days of the fishery and other changes associated possibly with changes in effort. Peaks and troughs have been observed within all of the assessment units in the past with both rapid increases and rapid declines in landings. In all areas the lowest landings of the time series occurred during the 1970s and with the exception of LFA 27 the highest landings occurred during the last 5 years. Recent increases in landings (2005-2010) are believed to reflect increased abundance. The specific factors controlling abundance and subsequent landings have not been determined.

4.5.2 Catch Rates (CPUE)

Like landings, catch rates are affected by factors other than abundance. However they should be a better indicator of abundance since they CPUE incorporates trap hauls number so accounts for differences in the total effort. Where possible, statistical models are fit to CPUE data to account for extra variation that is independent of population abundance change.

Commercial CPUE for LFAs 27-33 comes from two sources: mandatory logs and voluntary logs. Mandatory logs were introduced in 2004-05. While return rates and data quality were initially low, in recent years return rates have been in the 90-100% range, and useable data in the 85-100% range. For this analysis the 3 most recent years are included. The short time series makes discussion of trends or levels very preliminary but as the time series lengthens, their value will increase. In future assessments the data will be available for catch rate modelling.

Voluntary logs began in the mid 1980s and thus cover a longer period than the mandatory logs. The number of logs kept is a small percentage of the total number of fishermen and in some assessment units the number of voluntary logs has declined in recent years. Two areas, LFA 27 and 33 maintained the numbers into recent years and these provide a means to compare the voluntary log catch rates with those of the mandatory logs from 2006 to 2009. For the years available the means from the voluntary logs are similar to the mandatory logs.

4.6 TABLES

***Table 4.1** – Historical lobster Landings. **NOTE:** 2010 figures are preliminary and underestimated for some LFAs. 2002-2010 values for LFA 27 do not include Gulf Region portion of LFA 27.*

Year	LFA27	LFA 28-31	LFA 32-33
1892	770	3252	6598
1893	916	3800	6884
1894	874	3591	7060
1895	1196	4065	7092
1896	1484	3095	7020
1897	1518	3095	6086
1898	1424	2975	6569
1899	1501	2933	5360
1900	1775	3293	5408
1901	1300	2445	4191
1902	696	2005	5315
1903	1412	1993	4071
1904	1509	1973	4457
1905	1564	2207	5508
1906	1317	1664	4408
1907	844	1365	4102
1908	927	1471	4217
1909	777	1133	3954
1910	983	1367	3374
1911	1129	1384	3942
1912	1114	1506	3471
1913	1214	1339	4014
1914	716	833	2664
1915	843	1085	3648
1916	831	1211	2573
1917	1177	855	2297
1918	836	679	1684
1919	1161	1084	2422
1920	1285	1214	2263
1921	887	695	3034
1922	1135	700	1303
1923	1038	734	1165
1924	715	516	1036
1925	721	833	1727
1926	904	1192	1794
1927	878	1313	1926
1928	862	1371	1704
1929	928	1659	1901
1930	874	1553	2330
1931	959	1718	2404
1932	1330	1918	2195
1933	1166	1466	1488
1934	1049	1255	1746
1935	940	1174	1782
1936	968	1053	1325
1937	936	1034	1647
1938	1069	1041	1279
1939	880	1041	1411
1940	642	850	1459
1941	769	969	1298
1942	744	764	1269
1943	816	716	1608
1944	1014	777	1625
1945	1084	686	2193
1946	1303	738	2301
1947	912	641	1241
1948	962	702	1301
1949	862	766	1392
1950	898	928	1530
1951	1099	1065	1797
1952	964	1197	1894
1953	1081	1323	2002
1954	1162	1413	1819
1955	1245	1394	1683
1956	916	1258	1733
1957	708	1178	1058
1958	838	1008	1154
1959	882	1068	1580
1960	953	916	1544
1961	955	682	1557
1962	970	856	1685
1963	843	807	1775
1964	778	586	1420
1965	899	429	1282
1966	786	386	888
1967	774	356	749
1968	766	266	1016
1969	540	273	1285
1970	713	296	1099
1971	674	370	1262
1972	641	326	810
1973	547	303	672
1974	748	235	736
1975	893	195	622
1976	749	178	468
1977	795	121	436
1978	838	88	266
1979	1014	104	465
1980	975	77	314
1981	1267	150	419
1982	1227	171	518
1983	1658	245	570
1984	1502	312	1184
1985	1721	356	1838
1986	2420	462	2669
1987	2763	602	3052
1988	3072	606	2811
1989	3714	871	2127
1990	3790	656	2340
1991	3526	720	2718
1992	2778	675	2153
1993	2458	520	2010
1994	2190	474	2230
1995	2142	462	1614
1996	1616	341	2050
1997	1379	279	2110
1998	1346	334	2413
1999	1419	342	2478
2000	1499	412	2745
2001	1818	473	2954
2002	1292	457	3111
2003	1540	642	2733
2004	1735	800	2295
2005	1919	1447	2927
2006	1820	2338	3197
2007	1910	2808	3660
2008	2674	3374	3261
2009	2130	3669	4254
2010	2083	2970	4040

***Table 4.2** – Lobster Landings 1947-2010 values that were less than the 25th percentile of the time series were classified as "negative", values between the 25th and 75th percentile were classified as "neutral" and values that were greater than the 75th percentile were classified as "positive". See NOTE in Table 4.1 caption.*

Year	LFA27	LFA28-29	LFA30	LFA31	LFA32	LFA28-32	SEASON	LFA33	LFA27-33
1947	912	117	103	421	333	974	1946-47	908	2794
1948	962	110	171	421	285	987	1947-48	1016	2965
1949	862	151	164	451	275	1041	1948-49	1117	3020
1950	898	177	162	589	384	1312	1949-50	1146	3356
1951	1090	246	191	628	501	1566	1950-51	1296	3961
1952	964	300	159	738	743	1940	1951-52	1151	4055
1953	1081	254	244	825	587	1910	1952-53	1415	4406
1954	1162	295	251	867	642	2055	1953-54	1177	4394
1955	1245	296	298	800	476	1870	1954-55	1207	4322
1956	916	282	265	711	440	1698	1955-56	1293	3907
1957	708	215	258	705	231	1409	1956-57	827	2944
1958	838	278	217	513	235	1243	1957-58	919	3000
1959	882	444	108	516	247	1315	1958-59	1333	3530
1960	953	285	159	472	360	1276	1959-60	1184	3413
1961	955	211	162	309	228	910	1960-61	1329	3194
1962	970	183	172	501	603	1459	1961-62	1082	3511
1963	843	140	142	525	690	1497	1962-63	1085	3425
1964	778	105	107	374	397	963	1963-64	1023	2784
1965	899	77	77	275	322	751	1964-65	960	2610
1966	786	69	81	236	177	563	1965-66	711	2060
1967	774	54	59	243	200	556	1966-67	549	1879
1968	766	45	52	169	213	479	1967-68	803	2048
1969	540	44	43	186	229	502	1968-69	1056	2098
1970	713	43	40	213	263	559	1969-70	836	2108
1971	674	59	48	263	276	646	1970-71	986	2306
1972	641	61	43	222	194	520	1971-72	616	1777
1973	547	56	29	218	187	490	1972-73	485	1522
1974	748	43	30	162	141	376	1973-74	595	1719
1975	893	39	37	119	91	286	1974-75	531	1710
1976	749	29	39	110	86	264	1975-76	382	1395
1977	795	24	29	68	84	205	1976-77	352	1352
1978	838	20	20	48	53	141	1977-78	213	1192
1979	1014	34	19	51	49	153	1978-79	416	1583
1980	975	23	13	41	66	143	1979-80	248	1366
1981	1267	45	35	70	56	206	1980-81	363	1836
1982	1227	50	27	94	70	241	1981-82	448	1916
1983	1658	63	62	120	109	354	1982-83	461	2473
1984	1502	74	69	169	140	452	1983-84	1044	2998
1985	1721	113	60	183	180	536	1984-85	1658	3915
1986	2420	154	85	223	284	746	1985-86	2385	5551
1987	2763	200	99	303	258	860	1986-87	2794	6417
1988	3072	203	77	326	222	828	1987-88	2589	6489
1989	3714	257	132	482	239	1110	1988-89	1888	6712
1990	3790	172	119	385	303	959	1989-90	2037	6786
1991	3526	168	151	401	298	1018	1990-91	2420	6964
1992	2778	150	167	358	304	979	1991-92	1849	5606
1993	2458	104	132	284	279	799	1992-93	1731	4988
1994	2190	104	130	240	262	736	1993-94	1968	4894
1995	2142	107	126	229	219	681	1994-95	1395	4218
1996	1616	75	90	176	225	566	1995-96	1825	4007
1997	1379	51	80	148	243	522	1996-97	1867	3768
1998	1346	64	70	200	309	643	1997-98	2104	4093
1999	1419	55	70	217	316	658	1998-99	2162	4239
2000	1499	59	54	299	448	860	1999-2000	2297	4656
2001	1818	71	98	304	433	906	2000-01	2521	5245
2002	1292	65	79	313	358	815	2001-02	2753	4860
2003	1540	138	73	431	389	1031	2002-03	2344	4915
2004	1735	198	84	518	289	1089	2003-04	2006	4830
2005	1919	411	112	924	403	1850	2004-05	2524	6293
2006	1820	654	187	1497	601	2939	2005-06	2596	7355
2007	1910	772	215	1821	620	3428	2006-07	3040	8378
2008	2674	1043	399	1932	687	4061	2007-08	2574	9309
2009	2130	1036	462	2171	776	4445	2008-09	3478	10053
2010	2083	796	357	1817	611	3581	2009-10	3429	9093

***Table 4.3** – Lobster Landings 1970-2010 values that were less than the 25th percentile of the time series were classified as "negative", values between the 25th and 75th percentile were classified as "neutral" and values that were greater than the 75th percentile were classified as "positive". See NOTE in Table 4.1 caption.*

Year	LFA27	LFA28-29	LFA30	LFA31	LFA32	LFA28-32
1970	713	43	40	213	263	559
1971	674	59	48	263	276	646
1972	641	61	43	222	194	520
1973	547	56	29	218	187	490
1974	748	43	30	162	141	376
1975	893	39	37	119	91	286
1976	749	29	39	110	86	264
1977	795	24	29	68	84	205
1978	838	20	20	48	53	141
1979	1014	34	19	51	49	153
1980	975	23	13	41	66	143
1981	1267	45	35	70	56	206
1982	1227	50	27	94	70	241
1983	1658	63	62	120	109	354
1984	1502	74	69	169	140	452
1985	1721	113	60	183	180	536
1986	2420	154	85	223	284	746
1987	2763	200	99	303	258	860
1988	3072	203	77	326	222	828
1989	3714	257	132	482	239	1110
1990	3790	172	119	365	303	959
1991	3526	168	151	401	298	1018
1992	2778	150	167	358	304	979
1993	2458	104	132	284	279	799
1994	2190	104	130	240	262	736
1995	2142	107	126	229	219	681
1996	1616	75	90	176	225	566
1997	1379	51	80	148	243	522
1998	1346	64	70	200	309	643
1999	1419	55	70	217	316	658
2000	1499	59	54	299	448	860
2001	1818	71	98	304	433	906
2002	1292	65	79	313	358	815
2003	1540	138	73	431	389	1031
2004	1735	198	84	518	289	1089
2005	1919	411	112	924	403	1850
2006	1820	654	187	1497	601	2939
2007	1910	772	215	1821	620	3428
2008	2674	1043	399	1932	687	4061
2009	2130	1036	462	2171	776	4445
2010	2083	796	357	1817	611	3581

SEASON	LFA33	LFA27-33
1969-70	836	2108
1970-71	986	2306
1971-72	616	1777
1972-73	485	1522
1973-74	595	1719
1974-75	531	1710
1975-76	382	1395
1976-77	352	1352
1977-78	213	1192
1978-79	416	1583
1979-80	248	1366
1980-81	363	1836
1981-82	448	1916
1982-83	461	2473
1983-84	1044	2998
1984-85	1658	3915
1985-86	2385	5551
1986-87	2794	6417
1987-88	2589	6489
1988-89	1888	6712
1989-90	2037	6786
1990-91	2420	6964
1991-92	1849	5606
1992-93	1731	4988
1993-94	1968	4894
1994-95	1395	4218
1995-96	1825	4007
1996-97	1867	3768
1997-98	2104	4093
1998-99	2162	4239
1999-2000	2297	4656
2000-01	2521	5245
2001-02	2753	4860
2002-03	2344	4915
2003-04	2006	4830
2004-05	2524	6293
2005-06	2596	7355
2006-07	3040	8378
2007-08	2574	9309
2008-09	3478	10053
2009-2010	3429	9093

***Table 4.4** – LFA 27 Catch per unit effort (Kg/Trap Haul) by season and LFA 27 sub unit, 2005 to 2010.*

YEAR	Average CPUE		CPUE by Totals		% RECORDS INCLUDED
	NORTH	SOUTH	NORTH	SOUTH	
2004	0.402	0.294	0.407	0.279	3%
2005	0.418	0.332	0.423	0.324	17%
2006	0.517	0.416	0.520	0.389	46%
2007	0.460	0.431	0.465	0.430	52%
2008	0.485	0.477	0.489	0.474	89%
2009	0.411	0.404	0.420	0.402	85%
2010	0.479	0.489	0.488	0.489	84%

***Table 4.5** – LFA 28-32 Catch per unit effort (Kg/Trap Haul) by season 2005 to 2010.*

YEAR	LFA 28		
	average CPUE	CPUE by totals	% RECORDS INCLUDED
2005	0.28	0.281	9%
2006	0.443	0.425	36%
2007	no data meets criteria		
2008	0.307	0.312	73%
2009	0.311	0.297	93%
2010	0.241	0.232	100%
YEAR	LFA 29		
	average CPUE	CPUE by totals	% RECORDS INCLUDED
2005	0.713	0.75	7%
2006	1.184	1.176	40%
2007	1.322	1.332	60%
2008	1.333	1.335	96%
2009	1.368	1.36	96%
2010	1.231	1.245	95%
YEAR	LFA 30		
	average CPUE	CPUE by totals	% RECORDS INCLUDED
2005	0.61	0.61	5%
2006	0.75	0.754	32%
2007	1.334	1.357	52%
2008	1.688	1.692	98%
2009	1.894	1.913	100%
2010	1.69	1.711	100%

***Table 4.5 continued** – LFA 28-32 Catch per unit effort (Kg/Trap Haul) by season 2005 to 2010.*

YEAR	LFA 31A		
	average CPUE	CPUE by totals	% RECORDS INCLUDED
2005	0.655	0.675	11%
2006	0.919	0.902	78%
2007	1.049	1.06	88%
2008	1.116	1.132	98%
2009	1.131	1.152	99%
2010	1.038	1.055	99%
YEAR	LFA 31B		
	average CPUE	CPUE by totals	% RECORDS INCLUDED
2005	0.556	0.559	6%
2006	0.969	0.971	84%
2007	1.104	1.106	86%
2008	1.093	1.105	97%
2009	1.263	1.273	97%
2010	1.014	1.02	97%
YEAR	LFA 32		
	average CPUE	CPUE by totals	% RECORDS INCLUDED
2005	0.309	0.312	16%
2006	0.432	0.438	70%
2007	0.407	0.411	72%
2008	0.435	0.437	93%
2009	0.478	0.486	97%
2010	0.417	0.427	96%

***Table 4.6** – LFA 33 Catch per unit effort (Kg/Trap Haul) by season, period, and LFA 33 sub unit, 2005-06 to 2009-10.*

SEASON	Average CPUE						CPUE by Totals						% RECORDS INCLUDED
	EAST			WEST			EAST			WEST			
	FALL	WINTER	SPRING	FALL	WINTER	SPRING	FALL	WINTER	SPRING	FALL	WINTER	SPRING	
2005-06	0.420	0.175	0.210	0.649	0.281	0.218	0.435	0.169	0.209	0.656	0.273	0.220	60.7%
2006-07	0.523	0.167	0.190	0.845	0.293	0.212	0.543	0.176	0.192	0.855	0.298	0.214	71.2%
2007-08	0.448	0.152	0.236	0.624	0.205	0.257	0.448	0.152	0.246	0.608	0.203	0.259	88.3%
2008-09	0.579	0.179	0.251	0.876	0.266	0.283	0.619	0.192	0.260	0.909	0.268	0.280	86.5%
2009-10	0.568	0.161	0.255	1.063	0.269	0.331	0.596	0.170	0.262	1.095	0.283	0.335	85.1%

Table 4.7 – Voluntary log Catch per unit effort (Kg/Trap Haul) by Statistical District, sub unit and season.

Values that were less than the 25th percentile of the time series were classified as "negative", values between the 25th and 75th percentile were classified as "neutral", and values that were greater than the 75th percentile were classified as "positive.

Year	North SD 1	North SD 4	South SD 6	South SD 7	LFA27 North	LFA27 South
1985	0.38	0.84		0.41	0.55	
1986	0.57	0.88		0.58	0.69	
1987	0.55	0.74		0.60	0.62	
1988	0.43	0.69		0.68	0.52	
1989	0.47	0.85		0.81	0.61	
1990	0.57	0.89		0.76	0.69	
1991	0.55	0.87		0.69	0.67	
1992	0.45	0.71	0.45	0.59	0.55	0.54
1993	0.42	0.50	0.46	0.53	0.45	0.51
1994	0.36	0.47	0.36	0.43	0.40	0.41
1995	0.36	0.50	0.40	0.40	0.41	0.40
1996	0.29	0.44	0.35	0.32	0.35	0.33
1997	0.34	0.41	0.30	0.25	0.37	0.27
1998	0.33	0.42	0.31	0.28	0.36	0.29
1999	0.33	0.42	0.30	0.30	0.37	0.30
2000	0.39	0.52	0.37	0.29	0.44	0.31
2001	0.41	0.50	0.32	0.30	0.44	0.31
2002	0.39	0.41	0.31	0.27	0.39	0.28
2003	0.47	0.50	0.37	0.34	0.48	0.35
2004	0.43	0.48	0.36	0.41	0.45	0.39
2005	0.47	0.48	0.38	0.42	0.48	0.41
2006	0.55	0.42	0.44	0.47	0.50	0.46
2007	0.46	0.48	0.43	0.37	0.47	0.39
2008	0.57	0.57	0.60	0.37	0.57	0.45
2009	0.45	0.51	0.49	0.34	0.47	0.38

SEASON	SD 26	SD 27	SD. 28	SD 30	SD 31	LFA33 W
1984-1985			0.47		0.42	0.45
1985-1986			0.54		0.40	0.48
1986-1987			0.51		0.55	0.53
1987-1988			0.55		0.46	0.51
1988-1989			35		0.31	0.34
1989-1990			0.44		0.38	0.42
1990-1991			0.48		0.44	0.47
1991-1992			0.47		0.44	0.46
1992-1993	0.40		0.45		0.42	0.44
1993-1994	0.46		0.48	0.28	0.40	0.40
1994-1995	0.15		0.24	0.19	0.27	0.22
1995-1996	0.18		0.37	0.19	0.37	0.30
1996-1997	0.22		0.38	0.16	0.36	0.28
1997-1998	0.26	0.34	0.37	0.28	0.40	0.34
1998-1999	0.22	0.25	0.32	0.31	0.36	0.31
1999-2000	0.26		0.42	0.31	0.38	0.37
2000-2001	0.29	0.32	0.41	0.36	0.37	0.35
2001-2002	0.24	0.28	0.46	0.43	0.22	0.40
2002-2003	0.28	0.35	0.42	0.39	0.41	0.38
2003-2004	0.25		0.36	0.35	0.44	0.38
2004-2005	0.27	0.21	0.44	0.44	0.43	0.41
2005-2006	0.22	0.28	0.43	0.42	0.46	0.40
2006-2007	0.24	0.32	0.62	0.53	0.40	0.48

4.7 FIGURES

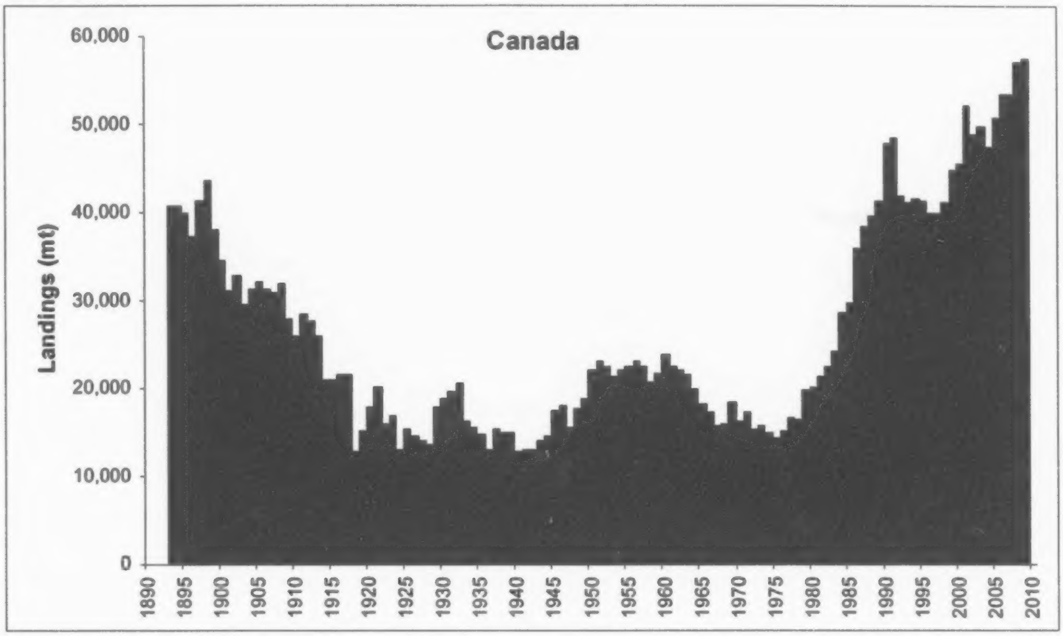


Figure 4.1 *– Canadian lobster landings 1892-2009 (2009 preliminary)*

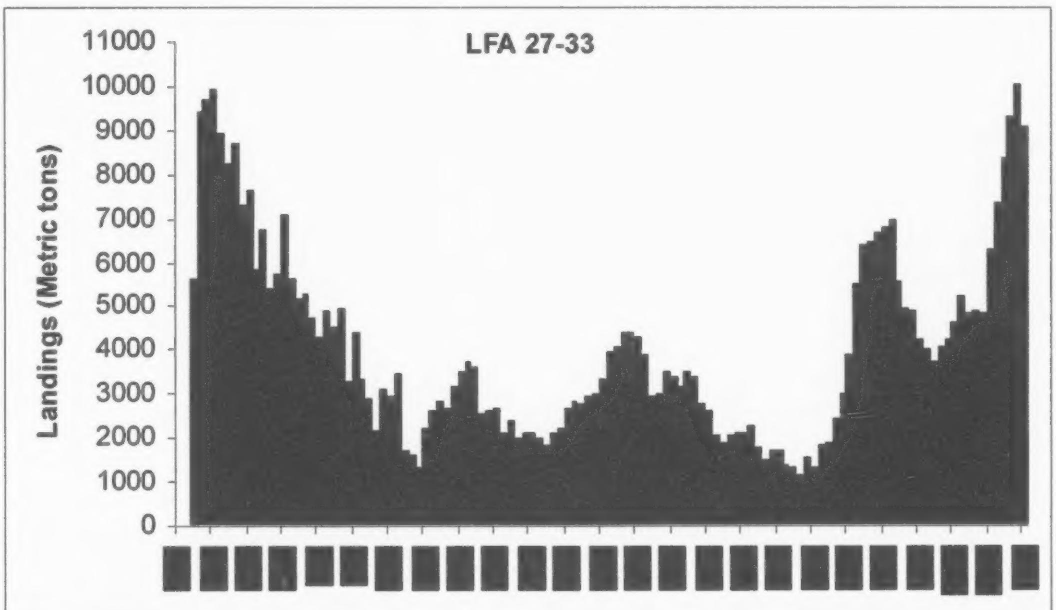


Figure 4.2 *– LFA 27-33 lobster landings 1892-2010 (2010 preliminary)*

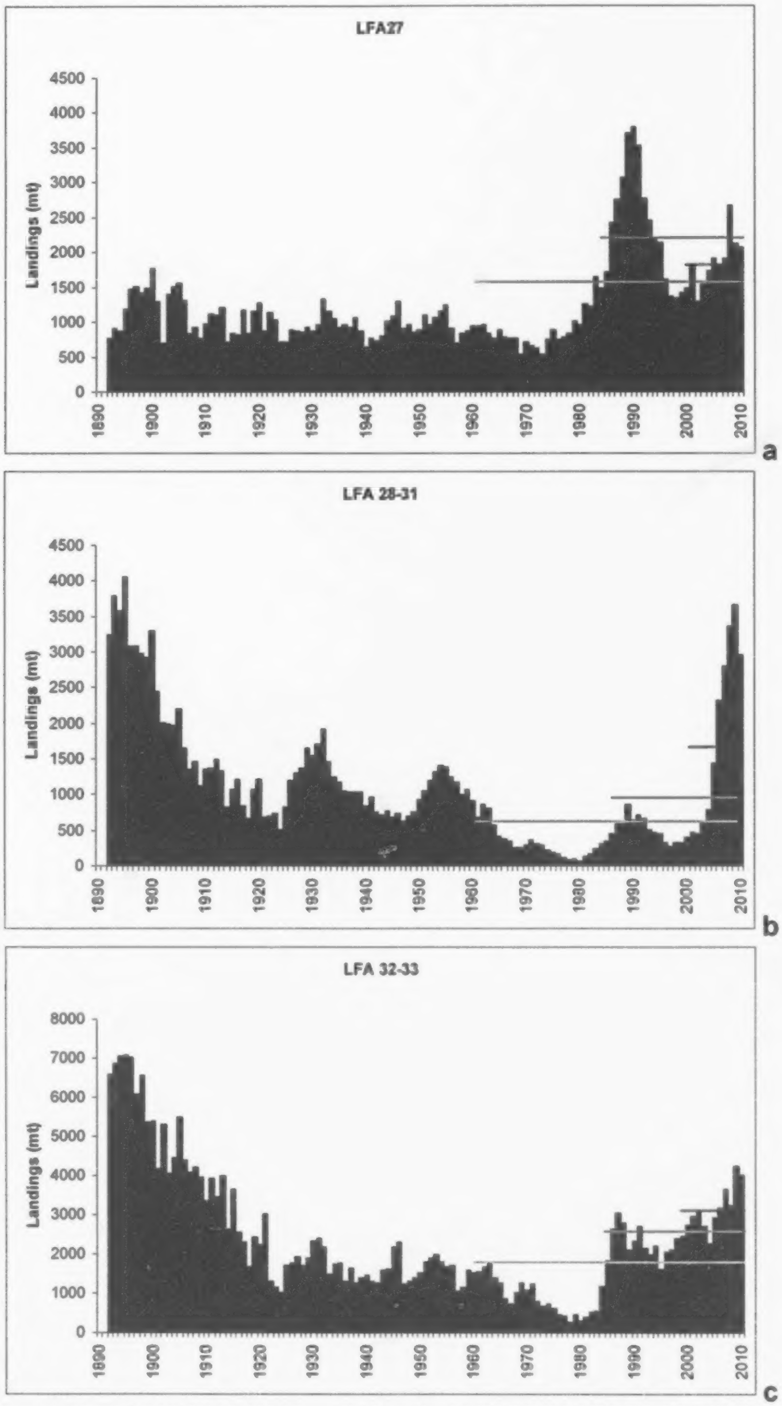


Figure 4.3 – Lobster landings 1892-2010 (2010 preliminary) a) LFA 27, b) LFA 28-31, c) LFA 32-33; showing mean landings for recent 10yr___, 25yr ___, and 50yr___. See NOTE in Table 4.1 caption.

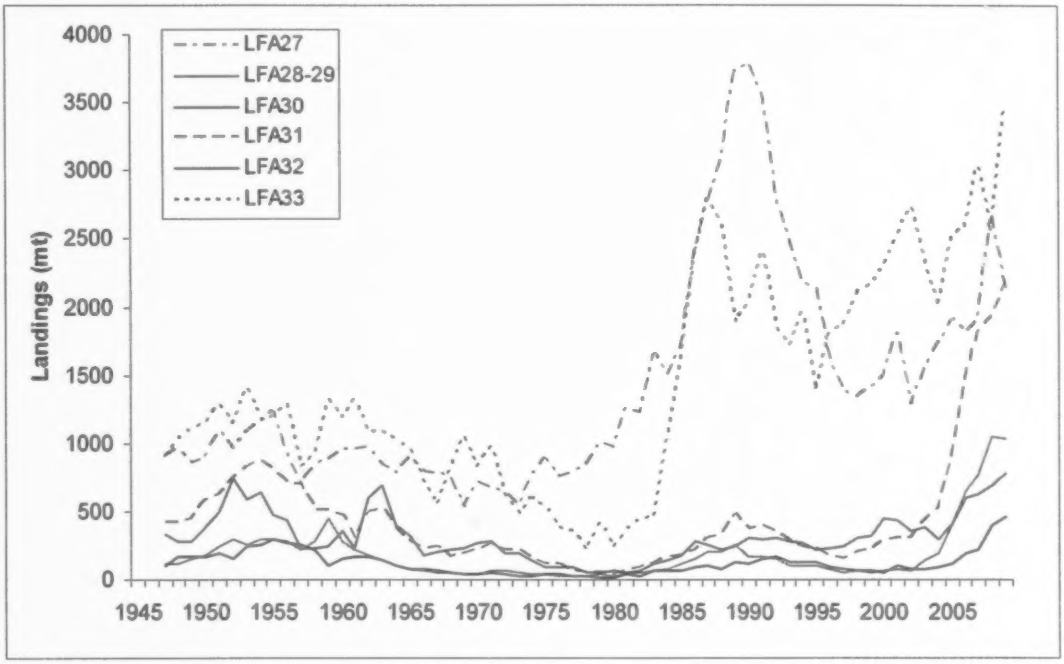


Figure 4.4 – Comparison of lobster landings by LFA 1947-2010 (2010 preliminary). See NOTE in Table 4.1 caption.

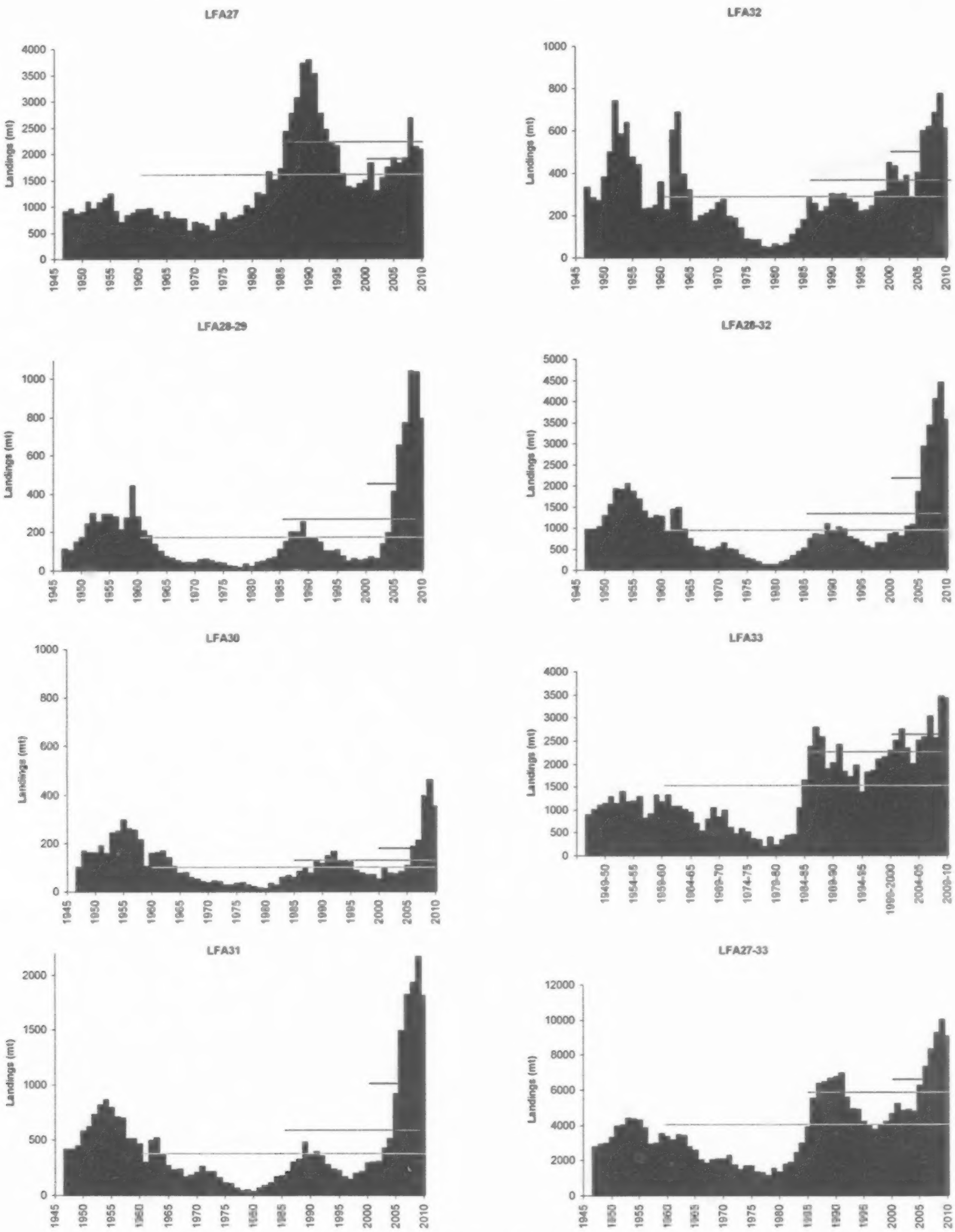


Figure 4.5 *– Lobster landings 1947-2010 (2010 preliminary) showing mean landings for 10yr___, 25yr___, and 50yr___. See NOTE in Table 4.1 caption.*

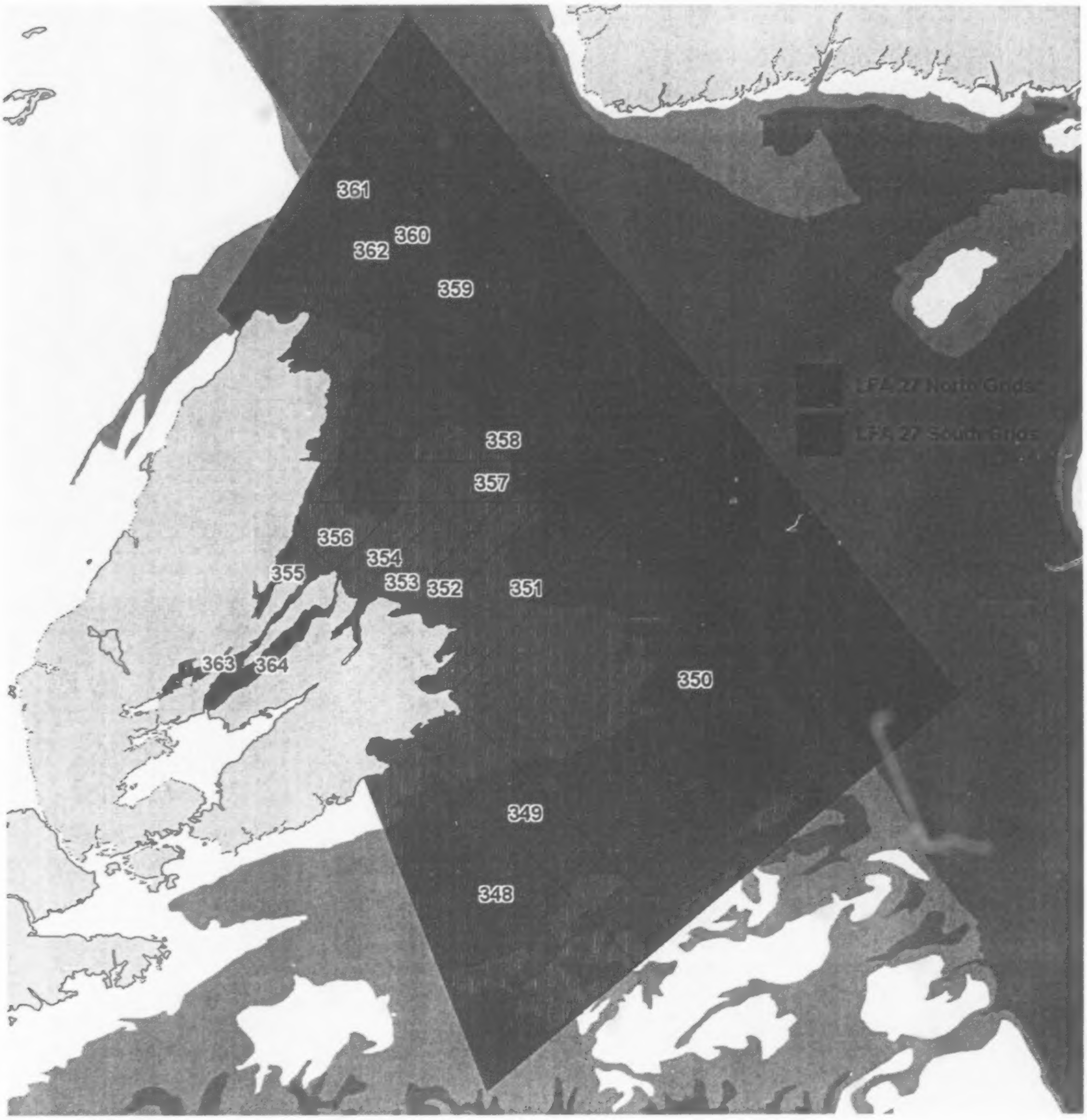


***Figure 4.6** – LFA 27 North and South Grids.*

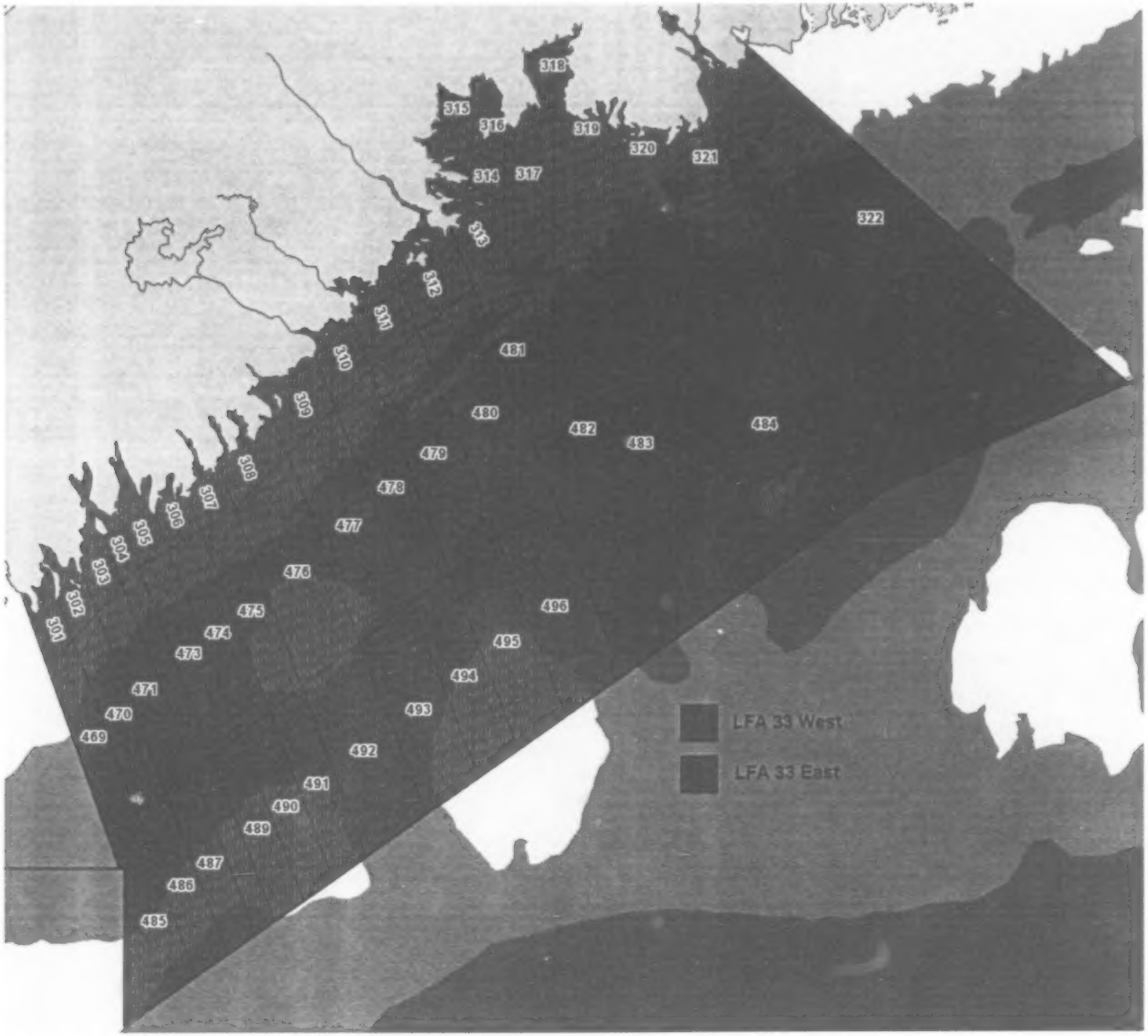


Figure 4.7 – LFA 33 East and West Grids.

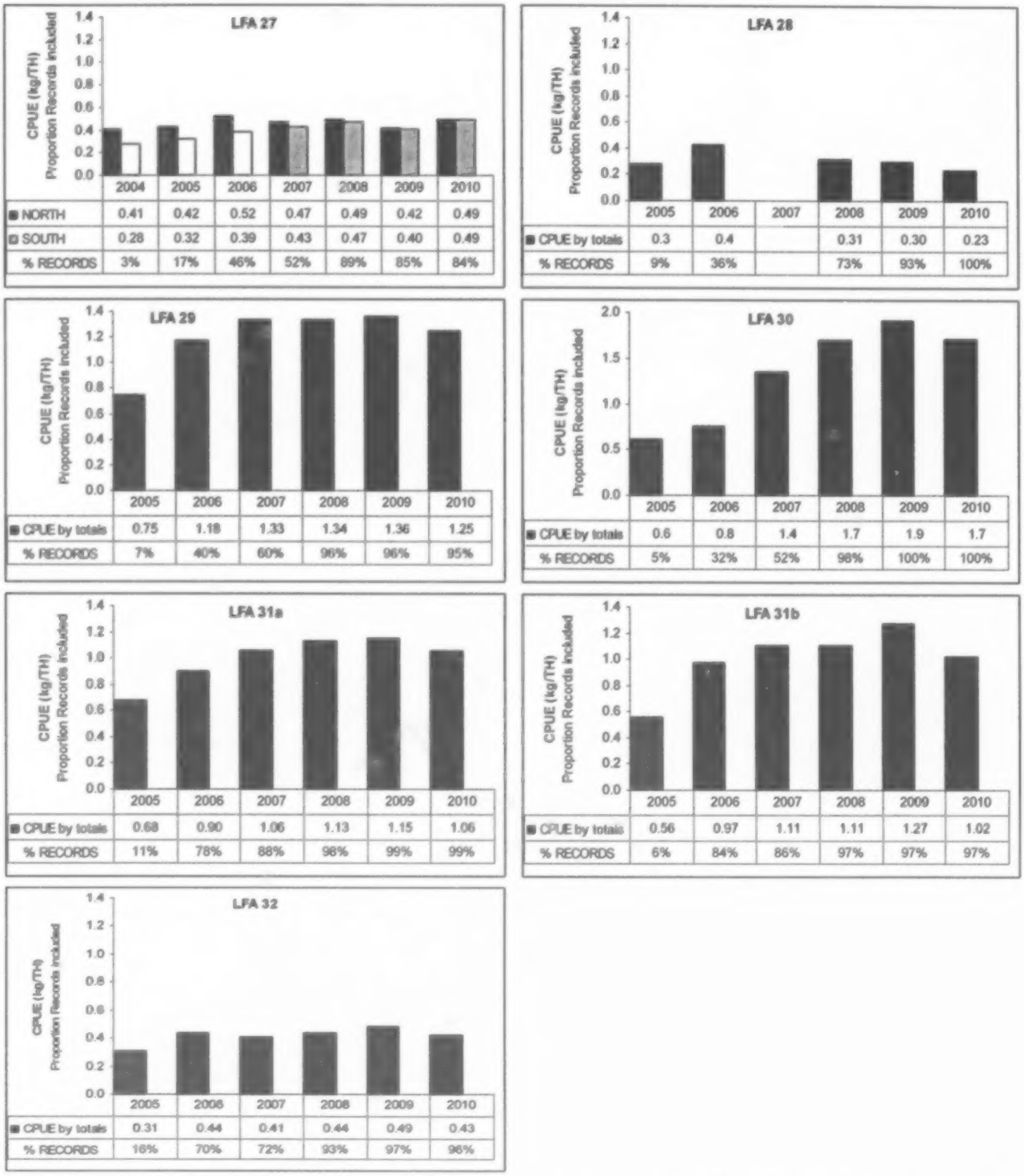
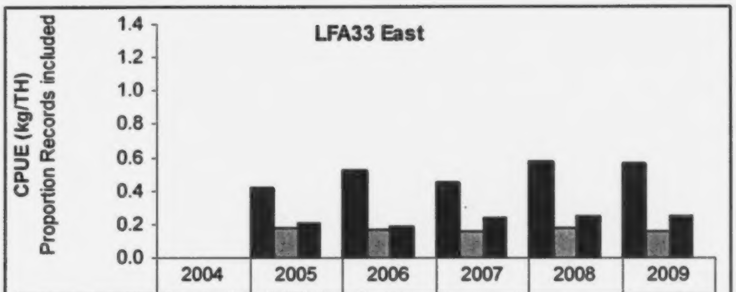
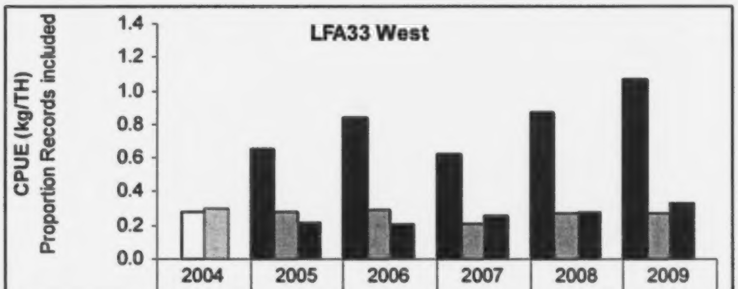


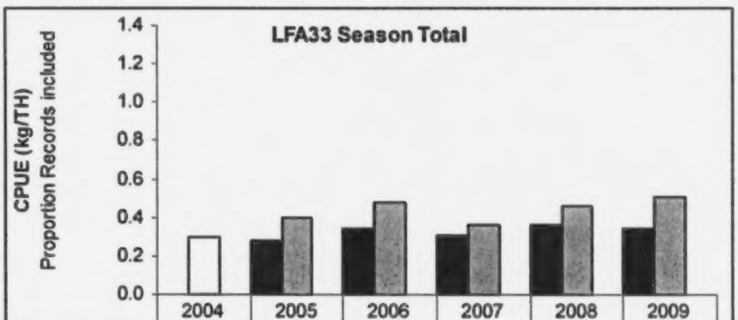
***Figure 4.8** – LFA 27-32 Catch per unit effort (Kg/Trap Haul) by season and LFA 27 sub unit, 2005 to 2010. Bars with the lighter shade of blue represent data with less than 50% of the records.*



	2004	2005	2006	2007	2008	2009
fall		0.42	0.52	0.45	0.58	0.57
w inter		0.17	0.17	0.15	0.18	0.16
spring		0.21	0.19	0.24	0.25	0.26
% RECORDS	0.5%	61%	71%	88%	87%	85%



	2004	2005	2006	2007	2008	2009
fall		0.65	0.84	0.62	0.88	1.06
w inter	0.28	0.28	0.29	0.20	0.27	0.27
spring	0.30	0.22	0.21	0.26	0.28	0.33
% RECORDS	0.5%	61%	71%	88%	87%	85%



	2004	2005	2006	2007	2008	2009
East		0.28	0.34	0.31	0.37	0.35
West	0.29	0.40	0.48	0.36	0.46	0.50
% RECORDS	0.5%	61%	71%	88%	87%	85%

***Figure 4.9** – LFA 33 Catch per unit effort (Kg/Trap Haul) by season, period, and LFA 33 sub unit, 2005-06 to 2009-10. Bars with no colour represent data with less than 50% of the records.*

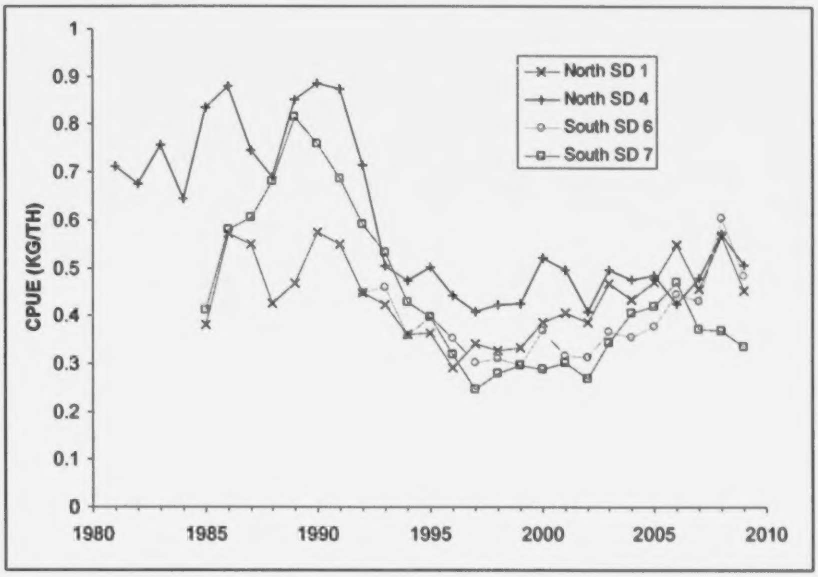
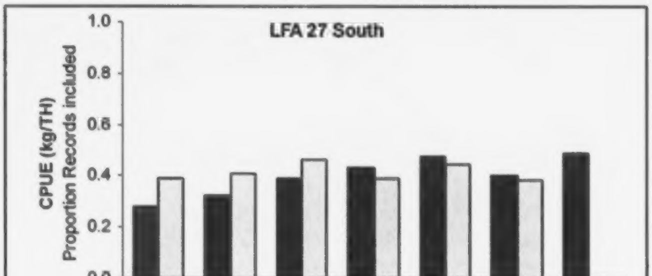
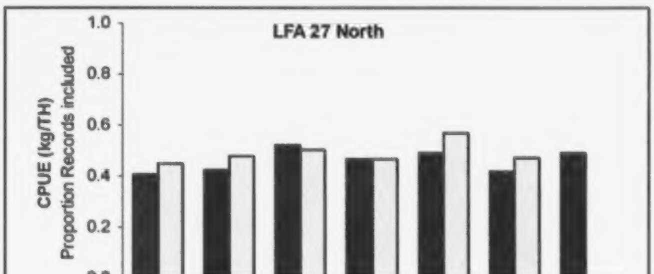


Figure 4.10 *– LFA 27 voluntary log Catch per unit effort (Kg/Trap Haul) by Statistical District and season, 1981-2009.*

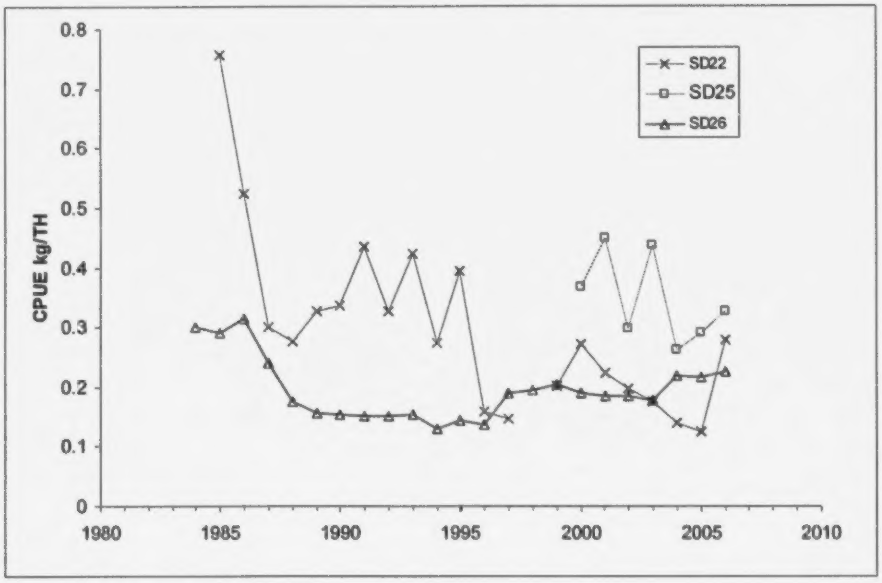


	2004	2005	2006	2007	2008	2009	2010
■ Compulsary	0.28	0.32	0.39	0.43	0.47	0.40	0.49
□ Voluntary	0.39059	0.40389	0.46154	0.39047	0.44511	0.38401	



	2004	2005	2006	2007	2008	2009	2010
■ Compulsary	0.41	0.42	0.52	0.47	0.49	0.42	0.49
□ Voluntary	0.449	0.476	0.503	0.465	0.570	0.474	

Figure 4.11 *– Comparison of mandatory logbooks and LFA 27 voluntary log Catch per unit effort (Kg/Trap Haul) by sub unit 2004.*



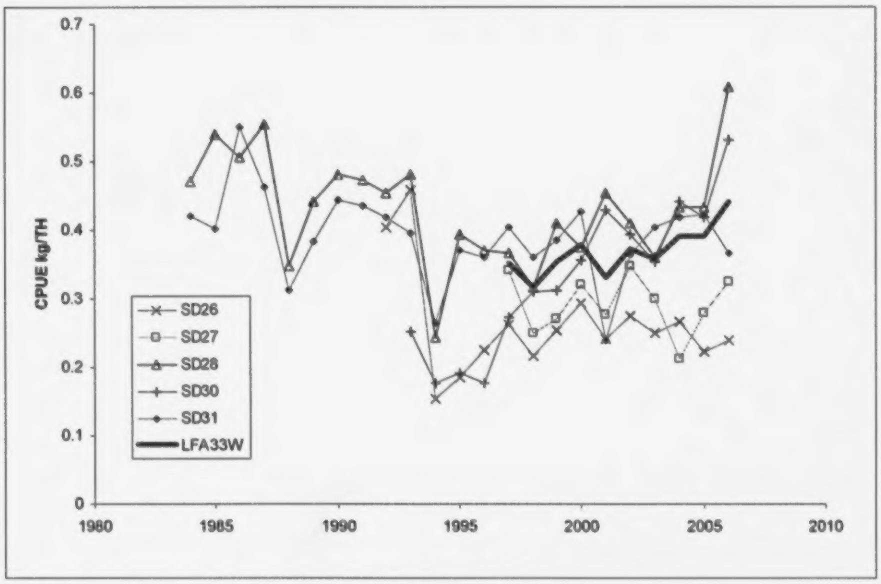
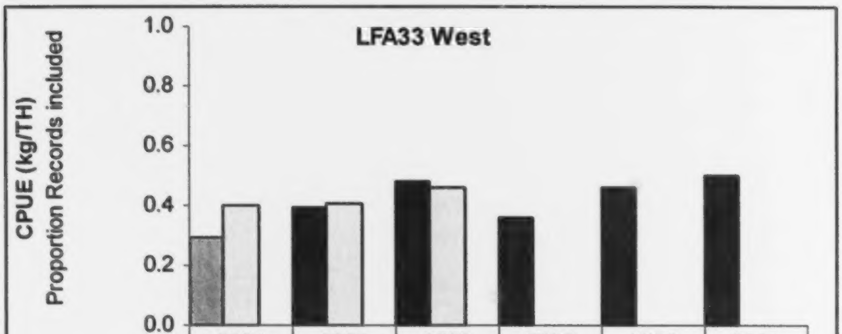


***Figure 4.12** – LFA 33 voluntary log Catch per unit effort (Kg/Trap Haul) by Statistical District and season, 1981-2009. Upper figure are SD in LFA 33-East; lower figure are in SD LFA33-W.*



	2004	2005	2006	2007	2008	2009
West	0.29	0.40	0.48	0.36	0.46	0.50
Vol Log	0.4	0.41	0.46			
% RECORDS	0.5%	61%	71%	88%	87%	85%

***Figure 4.13** – Comparison of mandatory logbooks and LFA 33 West voluntary log Catch per unit effort (Kg/Trap Haul).*

5. INDICATORS OF ABUNDANCE FOR LEGAL SIZES, RECRUITS AND SPAWNERS - CPUE IN FSRS TRAPS

5.1 INTRODUCTION

Annual mean commercial catch rates from a fishery are often used as indicators of population abundance with changes in the annual values expected to reflect similar changes in the population being fished (Quinn and Deriso 1999). We consider catch rate as an index of abundance, but make no assumption about the form of the relationship between catch rate and abundance. See section 4.1 for further discussion.

Given that catch rates are affected by factors other than abundance such as time period and area fished, statistical models are fit to these data to account for some of the variation that is independent of population change. Once these other effects have been accounted for, trends in the catch rate date can be investigated as potential indicators of population change.

Data from FSRS traps may be the best source of catch rate data available for LFAs 27-33 in that they come from standard traps fished in fixed locations. They are not totally fishery-independent in that they are hauled only during the fishing season when project participants are tending their commercial gear. In addition there have been changes in participation that need to be accounted for.

Here we document a statistical model of CPUE from the FSRS traps in LFA 27 as an example of what could be applied in the other assessment units (LFAs 29-32 and LFA 33).

5.2 METHODS

Tremblay et al. (2009) used a catch rate model for data from the FSRS traps from 1999-2006 for separate areas within the range of the project traps (Fig. 3.4). The catch rate (number per trap haul) of prerecruits and legal sizes in FSRS traps was standardised for the effect of week, fisher and year using a log-linear model (Quinn & Deriso 1999; Pezzack et al. 2006):

$$\mathrm{Log}_e(\mathrm{CPUE}) = \mathrm{week} + \mathrm{fisher} + \mathrm{year}$$

The data were aggregated by week for the model because there were many zero observations in the daily data. Week was a covariate and fisher and year were factors. No interaction effects were examined. Area was not included in the model, because different areas are open for fishing in different months and because fishers operate in only one area.

Here we build on that model and attempt to incorporate the effects of subarea, fisherman and other sizes. We use LFA 27 as a case study.

The data are from the period 1999-2009. The number of FSRS participants (=fishermen) varied across areas and years (Table 3.11). The FSRS size groups were aggregated to form "legal" and "sublegal" size groups. The definition of these size groups changed over the period as the legal size increased in LFA 27 (Table 5.1).

5.2.1. Relationships Between CPUE of Legals and Sublegals

A behavioral component to lobster catchability is recognized (Miller 1990) and smaller lobsters generally have lower catchability than larger lobsters presumably because larger lobsters are threatening to smaller lobsters (Miller 1990, Tremblay and Smith 2001). For other species of lobster (e.g. rock lobster) it has been shown that large lobsters can inhibit the entry of smaller lobsters into traps (e.g. Frusher and Hoenig 2001). If this is the case for the sizes of lobster under study here, there are implications both for CPUE modeling and for the use of change in ratio methods for estimating exploitation (Section 8). The potential negative correlation between of the number of sublegal sized lobsters and legal sized lobsters was investigated through initial visual inspection of plots together with inclusion of sublegal lobsters in the model of legal size catch rates.

5.2.2. CPUE Models – Legal Sizes

We aggregated the data by week to reduce the number of records of zero lobsters. Aggregating the data by week within fisherman records resulted in the following R dataframe.

```
("LFA27.week.CPUE.2")
str(LFA27.week.CPUE.2)
'data.frame':    2522 obs. of  15 variables:
$ Vessel.Code      : Factor w/ 44 levels "1002","1006",..: 1 1 1 1 1 1 1  $ YEAR
: Factor w/ 11 levels "1999","2000",..: 1 1 1 1 1 1 1  $ wos          : num  1 2
3 4 5 6 7 8 9 9 ...
$ total.short     : int  14 26 23 29 44 32 18 29 23 33 ...
$ total.legal     : int  33 14 17 11 14 9 0 4 5 3 ...
$ total.traps     : int  25 30 28 23 28 26 14 15 19 10 ...
$ s.CPUE          : num  0.56 0.867 0.821 1.261 1.571 ...
$ l.CPUE          : num  1.32 0.467 0.607 0.478 0.5 ...
$ t.CPUE          : num  1.88 1.33 1.43 1.74 2.07 ...
$ LFA             : int  27 27 27 27 27 27 27 27 27 27 ...
$ Location.number: Factor w/ 43 levels "1","2","3","4",..: 26 26 26 26  $ Port
: Factor w/ 22 levels "Alder Point",..: 22 22 22 22 22  $ subarea         :
Factor w/ 4 levels "27 central","27 north",..: 1 1 1  $ s.CPUE.int     : int  0
0 0 1 1 1 1 1 1 3 ...
$ wos2            : Factor w/ 9 levels "1","2","3","4",..: 1 2 3 4 5 6
```

After aggregation by week there were 66 records (of a total of 2522) with zero legal-sized lobsters (Fig. 5.1); these 66 records were dropped from the analysis.

Our initial approach was to model log (CPUE) as a function of week, year and fisherman, similar to Tremblay et al. (2009). Fisherman was considered a fixed effect. The model was converted to a Generalized Linear Model (GLM) to more readily extract the model CPUE in the original scale.

Evaluation of the effect of geographic location required a different approach. Lobster fishermen in LFA 27 fish in Statistical Districts 1,4, 6 or 7 (Fig. 3.2) and therefore fishermen effects in the model will be aliased with location effects. In addition, the number of fishermen in a statistical district varied over time making it difficult to extract a fishermen fixed effect independent of the year effect. Instead, catch rate was modelled as a function of the week of the season for each fisherman within a location and year with the parameter estimates for each fishermen set as random effects similar to the approach taken in Pezzack et al. (2006). That is, the parameters for each fisherman are represented as random samples from a population of parameters representing all fishermen in the LFA.

5.3. RESULTS AND DISCUSSION

5.2.1. Relationship Between Legal and Sublegal CPUE

Plots of the daily CPUE of legal and sublegal sizes are shown in Figs. 5.2-5.5. Fig. 5.2 and 5.3 show the daily averages for all fishermen; Figs. 5.4 and 5.5 show individual fishermen's CPUE.

As expected the daily CPUE of legal sizes declines as the season progresses whether looking at daily averages of all fishermen (Fig. 5.2) or daily CPUE of individual fishermen (Fig. 5.4). This is assumed to be due to removals by the fishery. The daily CPUE of sublegals on the other hand increases in most cases, whether considering the daily average (Fig. 5.3) or the individual fishermen's CPUE (Fig. 5.5).

Plots of daily CPUE of sublegals versus daily CPUE of legals for individual fishermen indicates there is no consistent relationship (Fig. 5.6). If anything there are more positive than negative relationships. From this analysis we conclude that although legal CPUE in the FSRS traps decreases during the season while sublegal CPUE increases, there is no causal relationship. This suggests that the increase in sublegal CPUE is a result of increased catchability due to temperature or some other factor rather than interaction with larger animals. If it was the latter we would expect a negative correlation between the CPUE of shorts and the CPUE of legal sizes.

To increase confidence in the above interpretation, we included CPUE of sublegal lobsters as one of the factors in some of the CPUE models of legal CPUE.

5.3.2. Initial CPUE Models – Legal Sizes

The relationship between the standard deviation and mean CPUE by area, fishermen and week of the season indicates that a model with a constant coefficient of variation could represent these data (Fig. 5.7). Either a lognormal or Gamma distribution could be used but the latter with a log link was chosen here to avoid complicated retransformation from the log scale back to the original scale of measurement.

Some of the effects seen consistently in the modeling are illustrated with the model that included Year, week of season and fisherman (=Vessel.code). All main effects were significant:

```
l.CPUE~YEAR      +      wos      +      Vessel.code,data=LFA27.week.CPUE.2,
family=Gamma(link="log"), na.action ="na.omit" )

Anova Table (Type II tests)
Response: l.CPUE
              LR Chisq Df Pr(>Chisq)
YEAR            126.79 10  < 2.2e-16 ***
wos             739.58  1  < 2.2e-16 ***
Vessel.Code     885.58 42  < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Residual plots indicate no major problems (Fig. 5.8)

Effects plots for week of season (wos) illustrate the significant decline in legal CPUE with season (Fig. 5.9). The Year effects plot shows no strong trends over the period 1999-2009 although there are sharp declines in 2002 and 2009 associated with increases in the minimum legal size (Fig. 5.9).

Addition of sublegal CPUE to the above model (new model = lfa27.glm2) indicates sublegal CPUE is a significant factor.

```
> Anova(lfa27.glm2)
Anova Table (Type II tests)

Response: l.CPUE
            LR Chisq Df Pr(>Chisq)
YEAR          116.28 10  < 2.2e-16 ***
wos           822.00  1  < 2.2e-16 ***
Vessel.Code   893.50 42  < 2.2e-16 ***
s.CPUE         60.94  1  5.881e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Addition of sublegal CPUE results in an improved fit as indicated by AIC:

```
AIC(lfa27.glm1,lfa27.glm2)
           df      AIC
lfa27.glm1 55 1842.319
lfa27.glm2 56 1785.295
```

The coefficient for sublegal CPUE is positive, as indicated by the effects plot for sublegal CPUE (Fig. 5.10).

5.3.3. Mixed Effects Models – Legal Sizes

The full model was defined as:

(1) $Log(CPUE)_{ijk}$ = (1+ Year + subarea + Year:subarea) + (week + Year:week + subarea:week + Year:subarea:week)

where, fixed effects were defined as:

1 = Overall intercept
Year= intercept for year
subarea = intercept for subarea
Year:subarea = intercept for interaction term

week = overall slope for week
Year:week = slope for week nested in year
subarea:week = slope for week nested in subarea
Year:subarea:week = slope for week nested in subarea and year.

and random effects:

b_{0i} = intercept for vessel i

b_{1i} = slope for week for vessel i

The random effects are assumed to be normally distributed with mean of 0 and variances, σ_0^2 and σ_1^2, respectively. A gamma model with log link was used for the CPUE. The analysis was conducted using the Correlated data package in SPLUS (vers. 8.2.0).

The analysis of deviance for the full model indicates that all terms were significant. The fit of the full model (Model.1) was compared with the following reduced models:

Model.2: no interaction terms
Model.3: interaction between subarea and Year only
Model.4: interaction between subarea and week only
Model.5: interaction between Year and week only

Model	Degrees of Freedom	AIC
1	92	3699.7
2	19	3753.3
3	49	3722.3
4	22	3740.6
5	19	3765.9

The fit of the full model indicates that the relationship between catch rate and week differs by year and subarea. The are some outliers in the residuals for the within-group fixed effects (Fig. 5.11) while most of the points exhibit range within -2 and 2 of zero. The northern area has a larger range of fitted values for the number/haul but the residuals associated with these points were within the range of the residuals for the other areas.

The distribution of random effects within subareas were distributed around zero within subareas (Fig. 5.12). Some of the vessels appear to be outliers with Vessel 1034 in the Northcentral being the most extreme (see also Fig. 5.13).

The catch rate for a subarea within a year at any one week will reflect the reduction in the population due to the catch removed up to that point in time. Since the amount of catch removed in the previous week(s) can vary over subarea and years, annual trends for each area were predicted by setting week to 0 (Fig. 5.14). The full model results in different trends by subarea. Removal of vessel 1034 from the analysis resulted in a slight change in the annual trend for the Northcentral area (not shown).

The trends over time in the 4 subareas indicate (i) only LFA 27 south shows a clear trend from 1999-2009, with increasing CPUEs of legal sizes from 2002 to 2009; (ii) 3 of 4 areas had some downward movement from 1999-2002 as size increases were phased in (Table 5.1); (iii) all had a drop in CPUE in 2007 following a size increase from 76 mm CL to 77.5 mm CL. The fact that the model CPUE picks up the drops in CPUE expected from changes to management measures increases confidence in the model.

5.3.4. Mixed Effects Models – Sublegal Sizes

The same model as in (1) was applied to the sublegal CPUE but interactions terms between week and subarea were not significant.

Terms	Degrees of Freedom	denDF	F-value	p-value
(Intercept)	1	2326	57.12	<.0001
YEAR	10	2326	82.74	<.0001
subarea	3	38	20.09	<.0001
Week of season	1	2326	74.08	<.0001
YEAR:subarea	30	2326	6.78	<.0001
YEAR:week of season	10	2326	4.35	<.0001
subarea:week of season	3	2326	0.52	0.6630
YEAR:subarea:week of season	30	2326	1.99	0.0011

The best model for these data consisted of main effects Year and subarea, Year and subarea interaction and week of season nested within Year. That is, the intercept was a function of Year and subarea while the change in CPUE with week of season was a function of Year only. CPUE increased over weeks in all years.

As was the case for the model for legal sizes, there are some outliers in the residuals for the within-group fixed effects (Fig. 5.15) while most of the points exhibit range within -2 and 2 of zero. Again the northern area had a larger range of fitted values for the number/haul but the residuals associated with these points were for the most part within the range of the residuals for the other areas.

The distribution of random effects within subareas were distributed around zero within subareas (Fig. 5.16). Again there were some outlier vessels, but none were the same as in the same plot for legal sizes (Fig. 5.12).

For sublegal sizes we base the annual index on predicted CPUE in week 9 rather than week 0 because sublegal cpue tended to increase over the course of the season.

The trends over time in the 4 subareas were all upwards, although they did not all increase at the same rate. All subareas showed a drop in 2009 for unknown reasons. For the 4 subareas, the mean of the predicted cpue for sublegals in 2008 and 2009 was 1.7-2.4 times higher than the predicted cpue for 2000.

5.3.5. Ovigerous Females

It should be possible to model the catch rate data for ovigerous females in a manner similar to the legal and sublegal sizes. One difference is the larger number of 0s in the data, even after aggregating by week. Of 2522 records (one record=one fisherman's catch per week), there were 299 records with a cpue=0 (Fig. 5.1).

5.4. SUMMARY

For development of an indicator of abundance, a statistical model of CPUE from the FSRS trap data in LFA 27 provides an example of what could be applied in the other assessment units (LFAs 29-32 and LFA 33).The CPUE of lobsters was used to develop indicators of abundance for sublegal

and legal size lobsters. In principle the same approach could be applied to ovigerous females with the caveat that the sample size is low.

The CPUE was modeled with a mixed effects model. CPUE was modeled as a function of the week of the season for each fisherman within a location and year with the parameter estimates for each fishermen set as random effects.
The fact that the effects of fisherman and location are aliased, together with changes in participation over time makes it difficult to extract a fisherman effect independent of the year effect. As such, catch rate was modeled as a function of the week of the season for each fisherman within a location and year with the parameter estimates for each fishermen set as random effects

The fit of the full model indicates that the relationship between the catch rate of legal sizes and week differs by year and subarea in LFA 27. The modeled CPUE for legal and sublegal sizes showed trends we would expect from other data and information, and the modeled CPUE likely provide the best abundance indicator possible.

5.5. TABLES

***Table 5.1** – Minimum legal size (MLS) by year in LFA 27.*

LFA	Year	MLS (mm)
27	1999	73
27	2000	73
27	2001	74.5
27	2002	76
27	2003	76
27	2004	76
27	2005	76
27	2006	76
27	2007	77.5
27	2008	79
27	2009	81

5.6. FIGURES

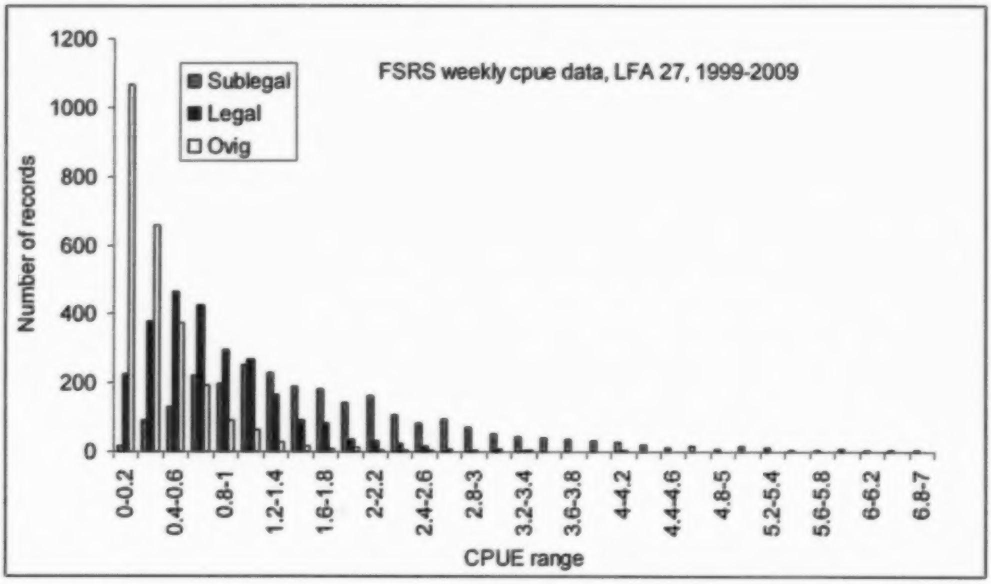


Figure 5.1 *– Catch rate frequency in LFA 27 FSRS data, 1999-2009. Total of 2522 records, each record representing data for one fisherman for one week (number per trap haul). Frequency distribution is shown for sublegals (= prerecruits), legal sizes and ovigerous females. For sublegal lobsters there were no records of 0 cpue; for legal lobsters there were 66 records with a cpue of 0; for ovigerous females there were 299 records with a cpue of 0.*

LFA 27 Legal cpue averaged over all fishermen by day(loess fit)

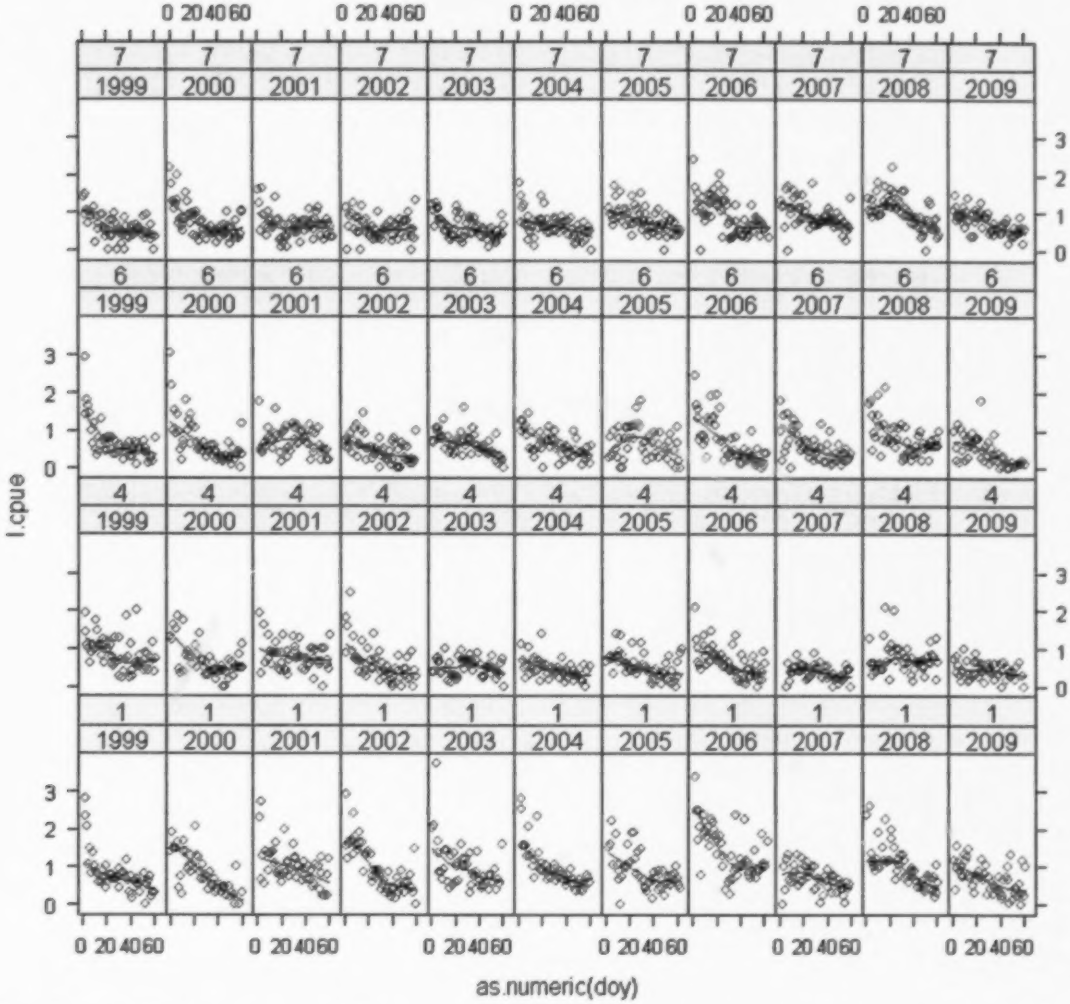
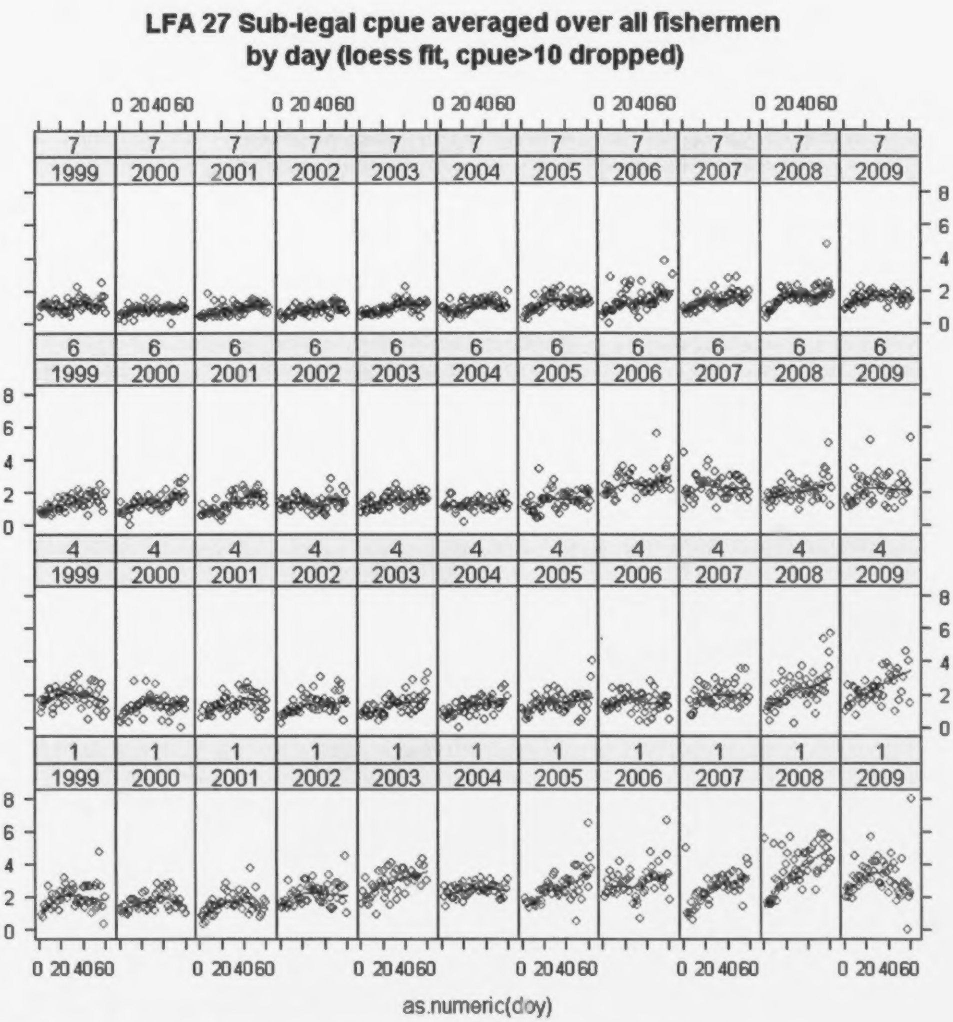
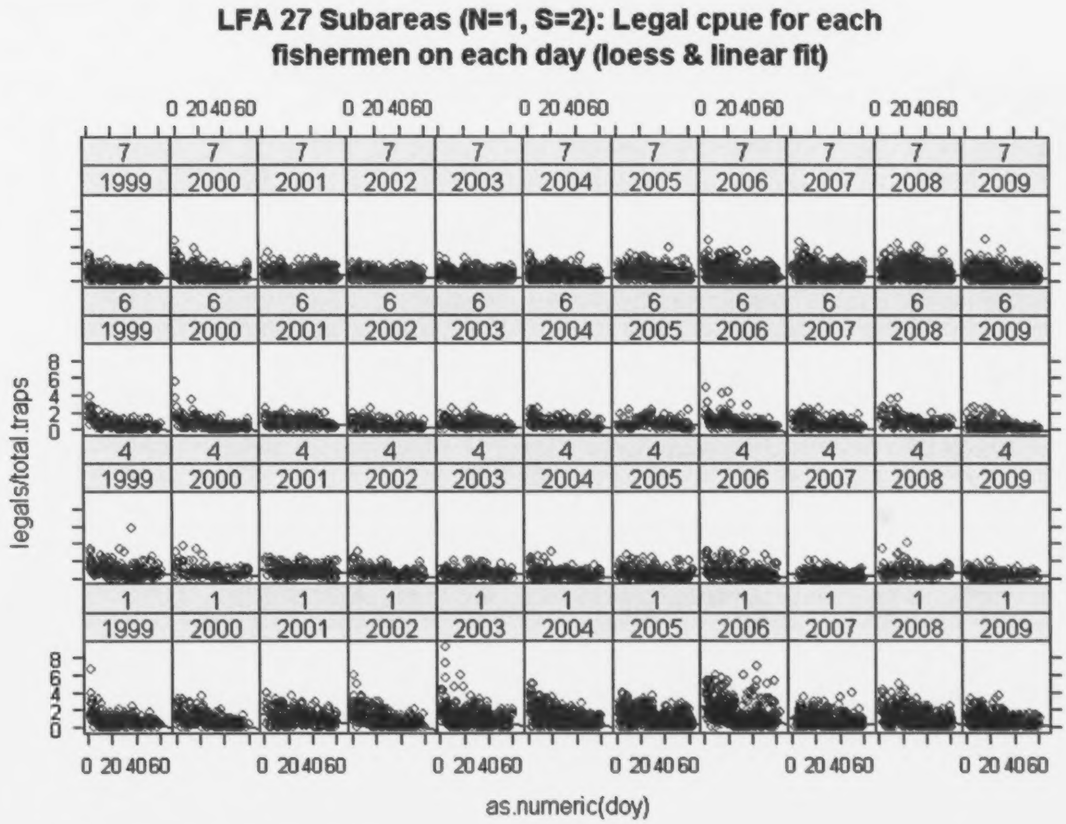


***Figure 5.2** – LFA 27 legal sizes CPUE (number per trap haul) averaged over all fishermen versus day of the season for each year and Statistical District (SD; SD = 1, 4, 6 and 7).*



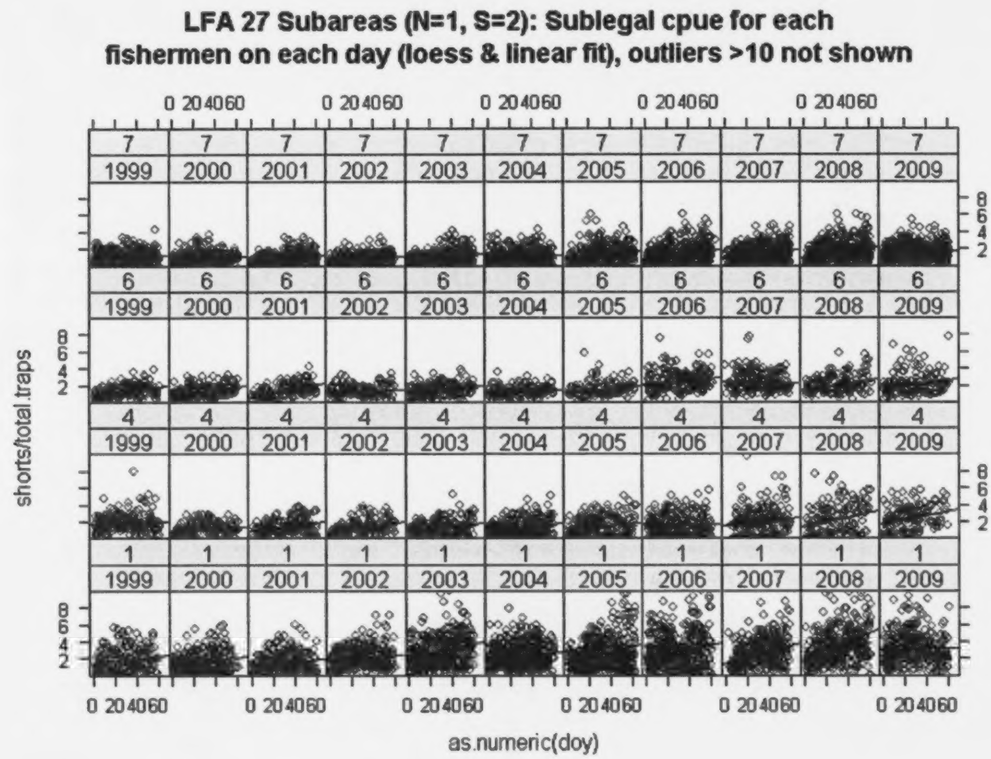

```
xyplot(s.CPUE~as.numeric(doy)|YEAR*SD,subset=s.CPUE<10,data=LFA27.daily.CPUE,
main="LFA 27 Sub-legal CPUE averaged over all fishermen
 by day (loess fit, CPUE>10 dropped)",
panel=function(x,y){
panel.xyplot(x,y,lab=5)
panel.loess(x,y,lty=1,col="red")})
```

***Figure 5.3** – LFA 27 sublegal sizes CPUE (number per trap haul) averaged over all fishermen versus day of the season for each year and Statistical District (SD; SD = 1, 4, 6 and 7).*



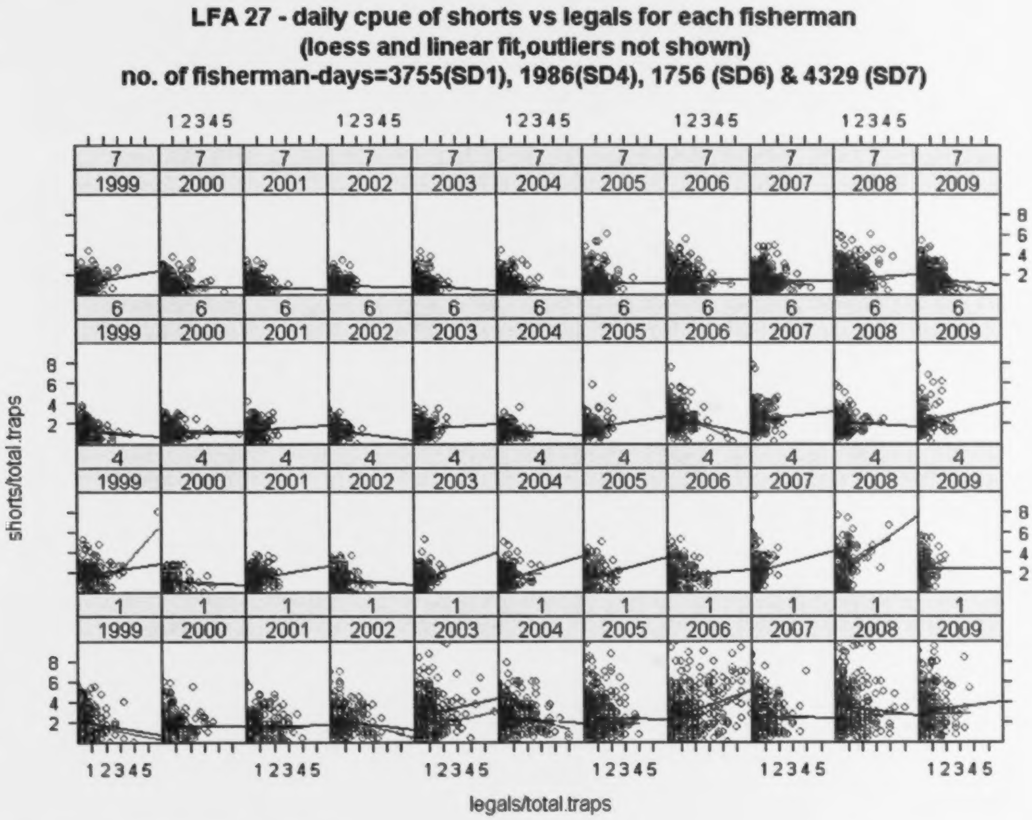

```
x11(width=8, height=6, pointsize=10)
xyplot(legals/total.traps~as.numeric(doy)|YEAR*factor(SD),data=LFA27,
main="LFA 27 Subareas (N=1, S=2): Legal CPUE for each
fishermen on each day (loess & linear fit)",
panel=function(x,y){
panel.xyplot(x,y,lab=5)
panel.loess(x,y,lty=1,col="red")
panel.lmline(x,y,col="black")})
```

***Figure 5.4** – LFA 27 legal sizes CPUE (number per trap haul) for individual fishermen versus day of the season for each year and Statistical District (SD; SD = 1, 4, 6 and 7).*




```
xyplot(shorts/total.traps~as.numeric(doy)|YEAR*factor(SD),data=LFA27,
main="LFA 27 Subareas (N=1, S=2): Sublegal CPUE for each
fishermen on each day (loess & linear fit), outliers >10 not shown",
ylim=c(0,10),
panel=function(x,y){
panel.xyplot(x,y,lab=5)
panel.loess(x,y,lty=1,col="red")
panel.lmline(x,y,col="black")})
```

***Figure 5.5** – LFA 27 sublegal sizes CPUE (number per trap haul) for individual fishermen versus day of the season for each year and Statistical District (SD; SD = 1, 4, 6 and 7).*




```
x11(width=9, height=7, pointsize=10)
xyplot(shorts/total.traps~legals/total.traps|YEAR*factor(SD),data=LFA27,
main="LFA 27 - daily CPUE of shorts vs legals for each fisherman
(loess and linear fit,outliers not shown)
no. of fisherman-days=3755(SD1), 1986(SD4), 1756 (SD6) & 4329 (SD7)",
xlim=c(0,6),ylim=c(0,10),
panel=function(x,y){
panel.xyplot(x,y,lab=5)
panel.loess(x,y,lty=1,col="red")
panel.lmline(x,y,col="black")})
```

***Figure 5.6** – LFA 27 daily CPUE (number per trap haul) of sublegal sizes versus daily CPUE of legal sizes for individual fishermen for each year and Statistical District (SD; SD = 1, 4, 6 and 7).*

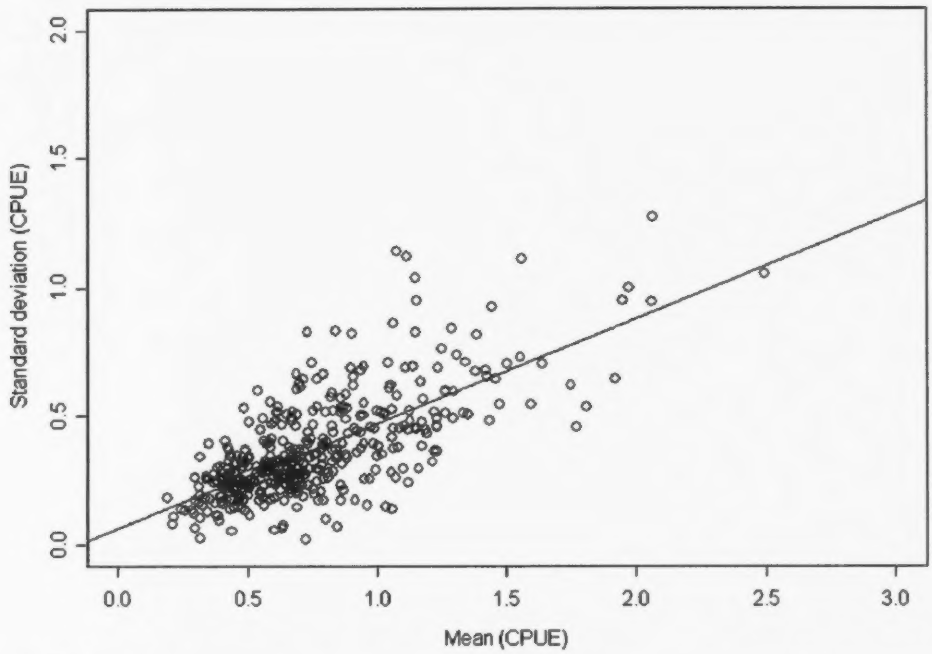


***Figure 5.7** – Plot of mean versus standard deviation of CPUE of legal sizes by area, fishermen and week in LFA 27. Solid line represents linear regression fit indicating increasing standard deviation with increasing mean. The slope of the line corresponds to a constant coefficient of variation for these data.*

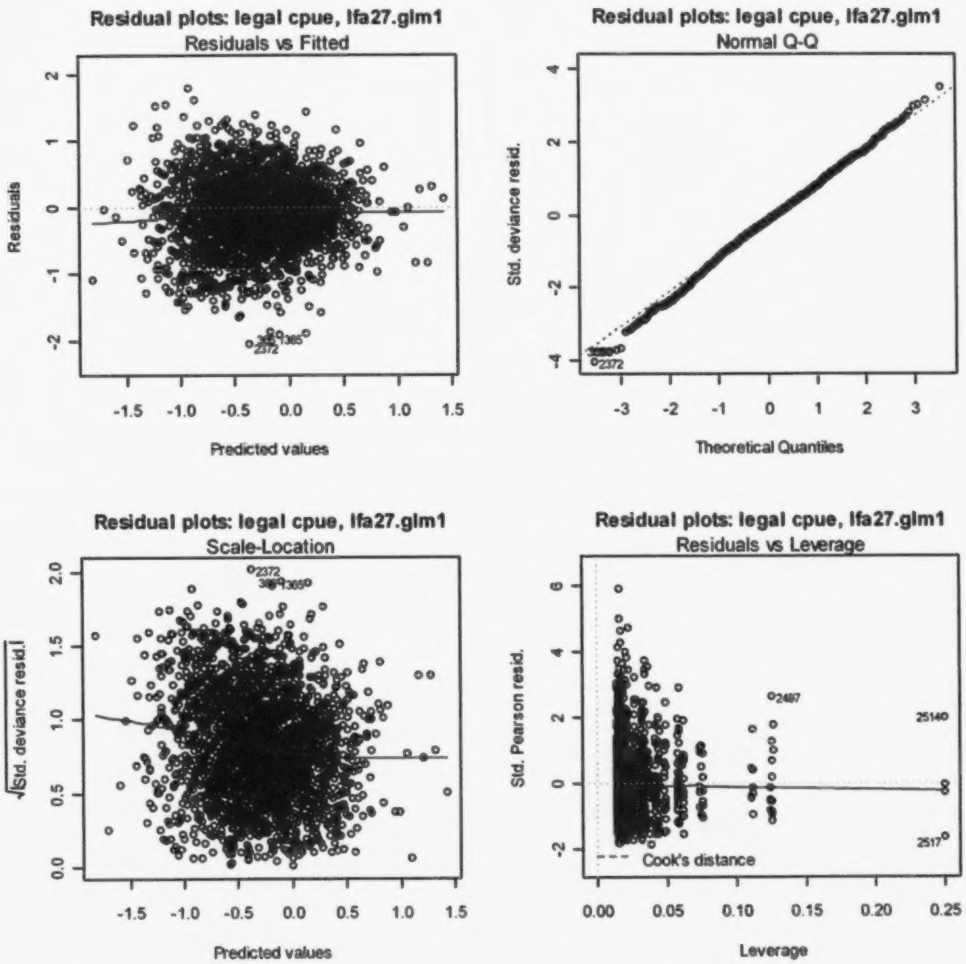


***Figure 5.8** – Residual plots for model of legal size lobster CPUE as a function of week of season, Year and fishermen.*

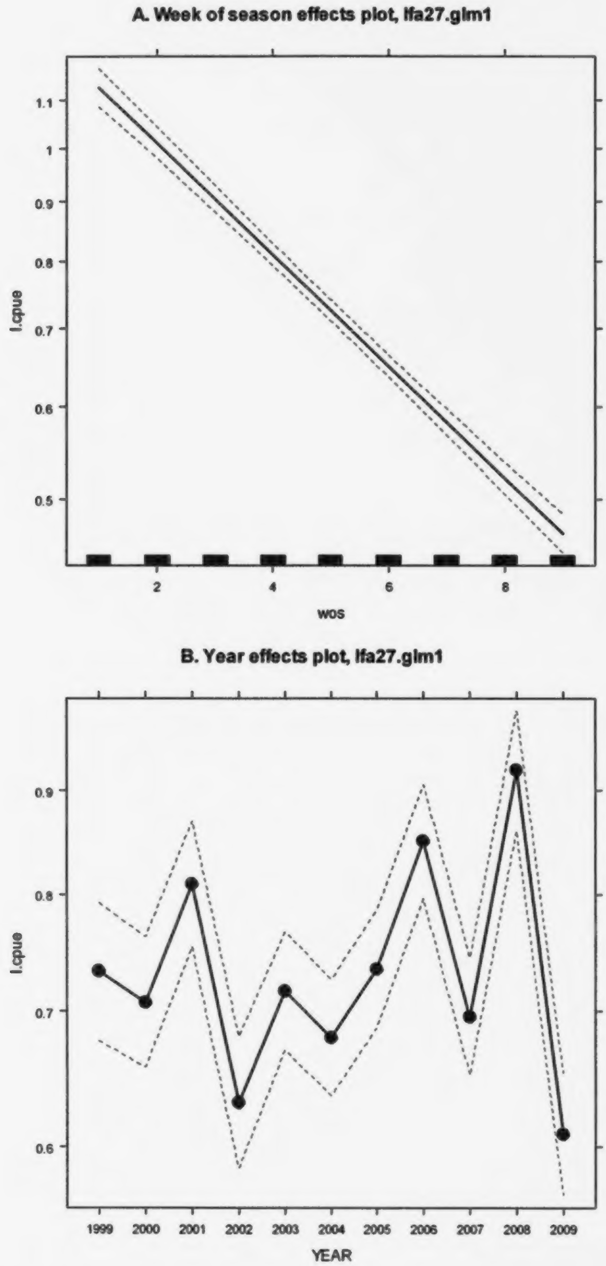


***Figure 5.9** – Legal size lobster CPUE as a function of week of season, year and fishermen. Effects plots for A. week and B. year.*

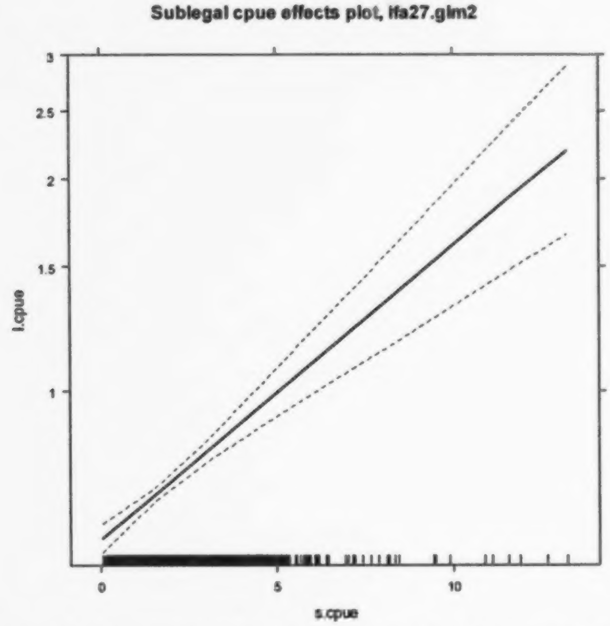


***Figure 5.10** – Effects plot for sublegal CPUE in model of legal size lobster CPUE as a function of week of season, year, fishermen and sublegal CPUE.*

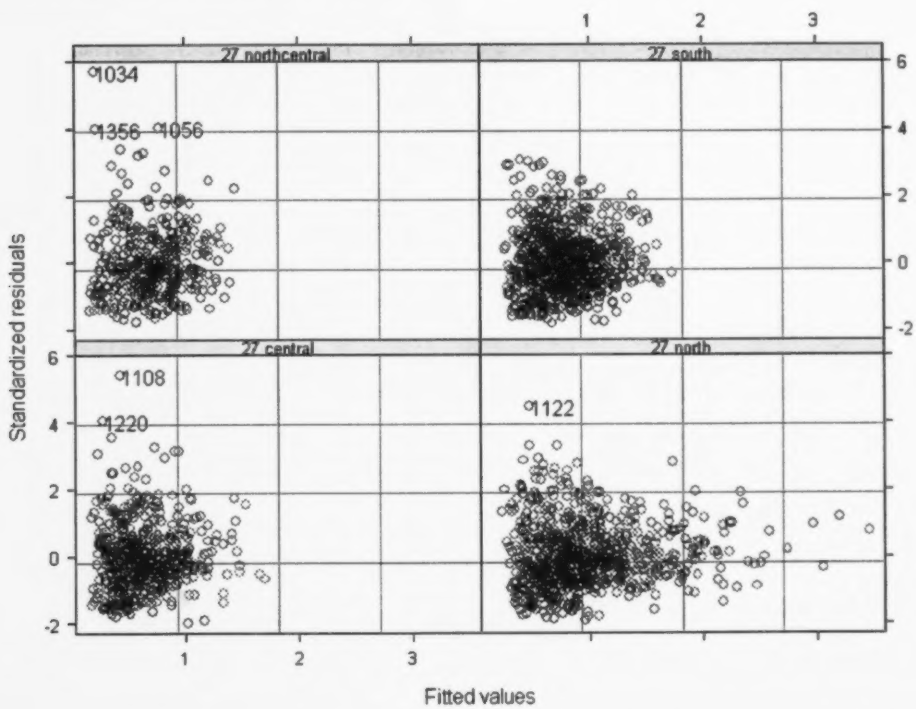


***Figure 5.11** – Residuals from fixed effects part of the model for catch rate of legal size lobsters as a function of year, subarea and week of season.*

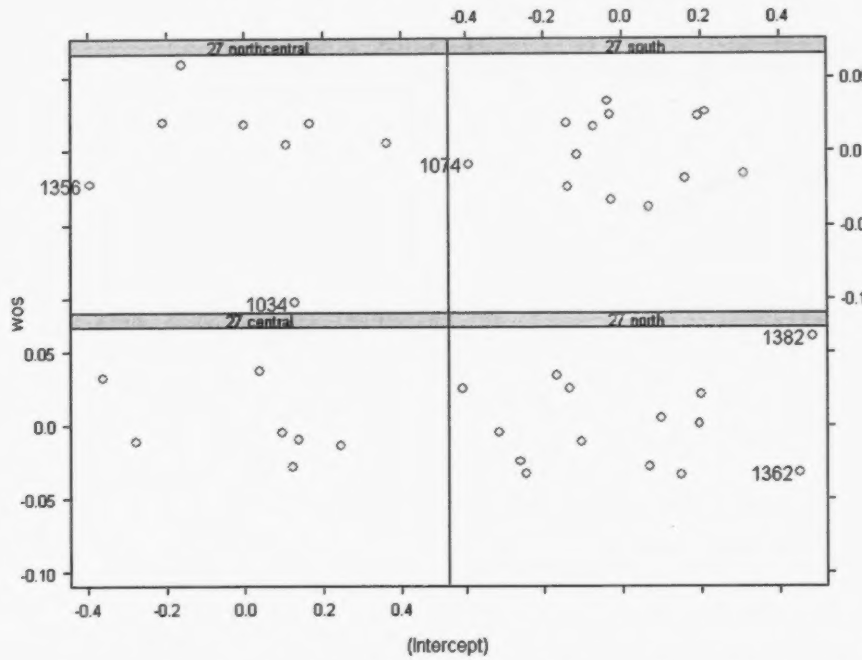


Figure 5.12 *– Random effects of relationship of catch rate of legal sizes with week of season. Outlying points identified by vessel code.*

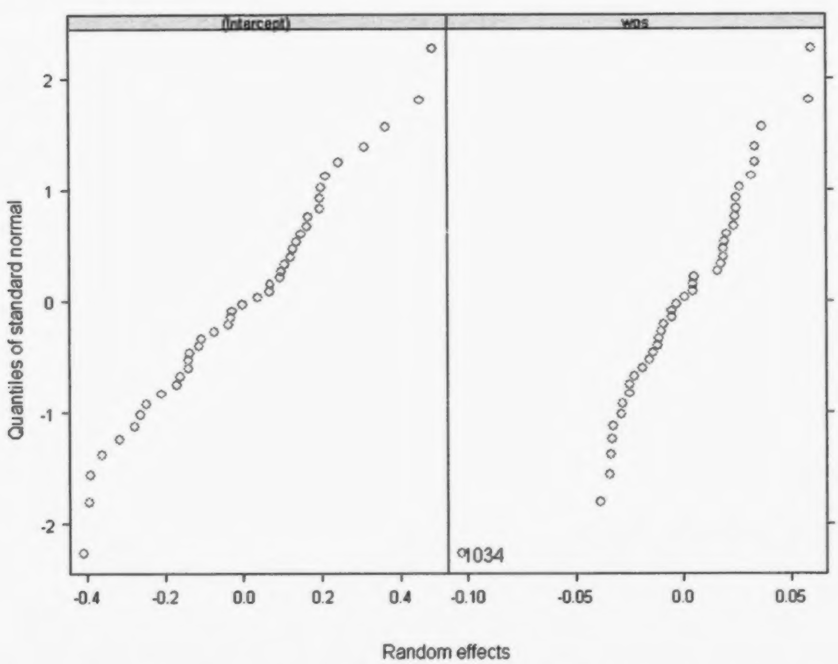


Figure 5.13 *– Quantile-quantile plots of random effects for intercept and slope for relationship of catch rate of legal sizes with week of season. Outlying point identified by vessel code.*

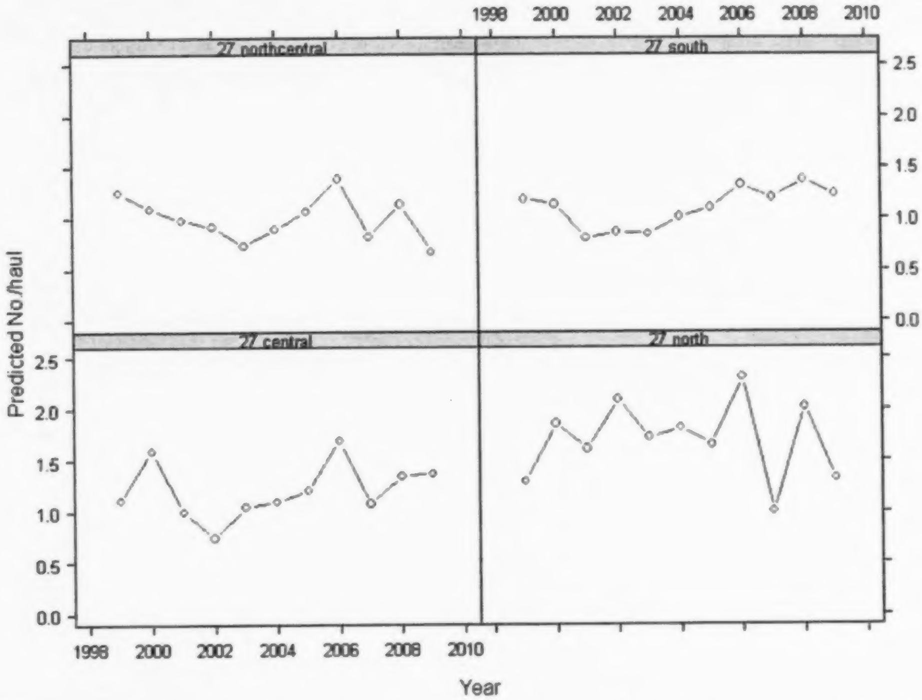


***Figure 5.14** – CPUE index of legal sizes from mixed-effects model of FSRS recruitment trap data. Annual index is estimated for week=0.*

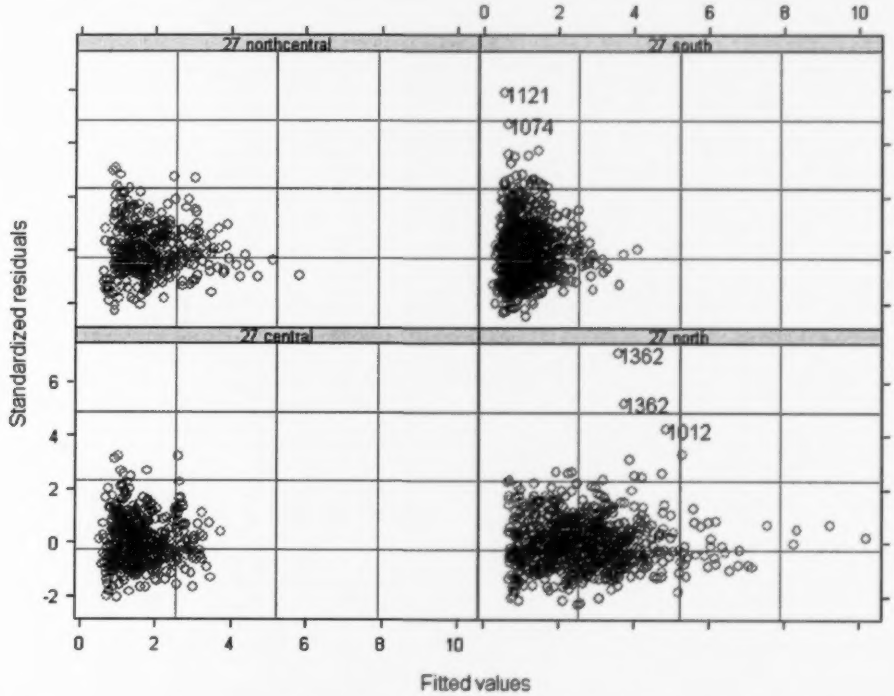


***Figure 5.15** – Residuals from fixed effects part of the model for catch rate of sublegal size lobsters as a function of year, subarea and week of season.*

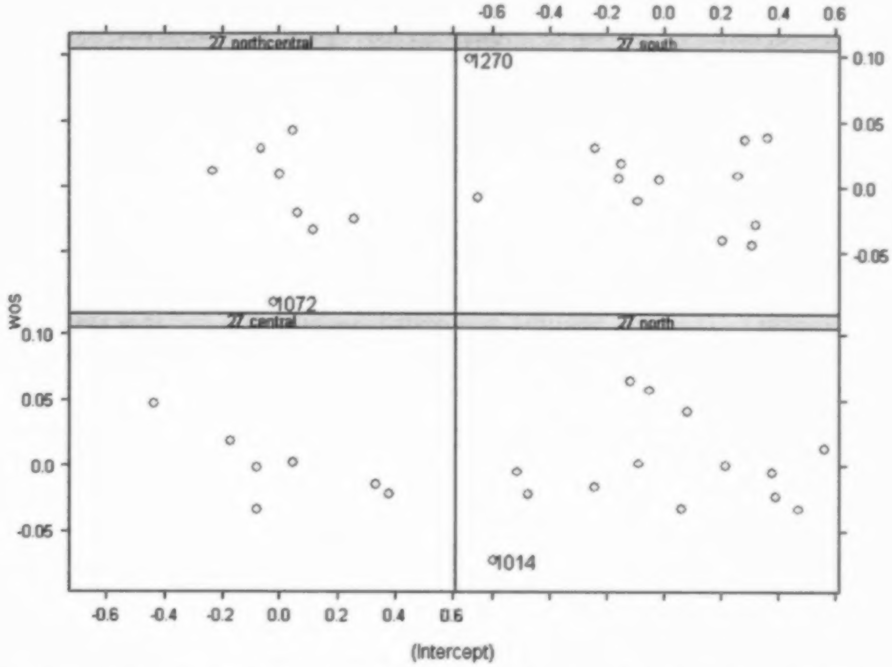


***Figure 5.16** – Random effects of relationship of catch rate of sublegal sizes with week of season. Outlying points identified by vessel code.*

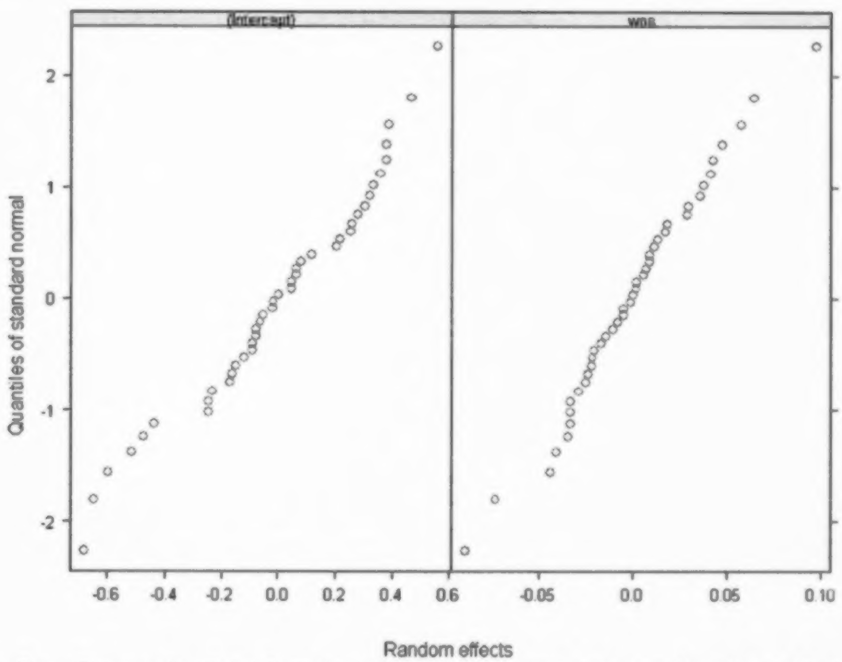


***Figure 5.17** – Quantile-quantile plots of random effects for intercept and slope for relationship of catch rate of sublegal sizes with week of season.*

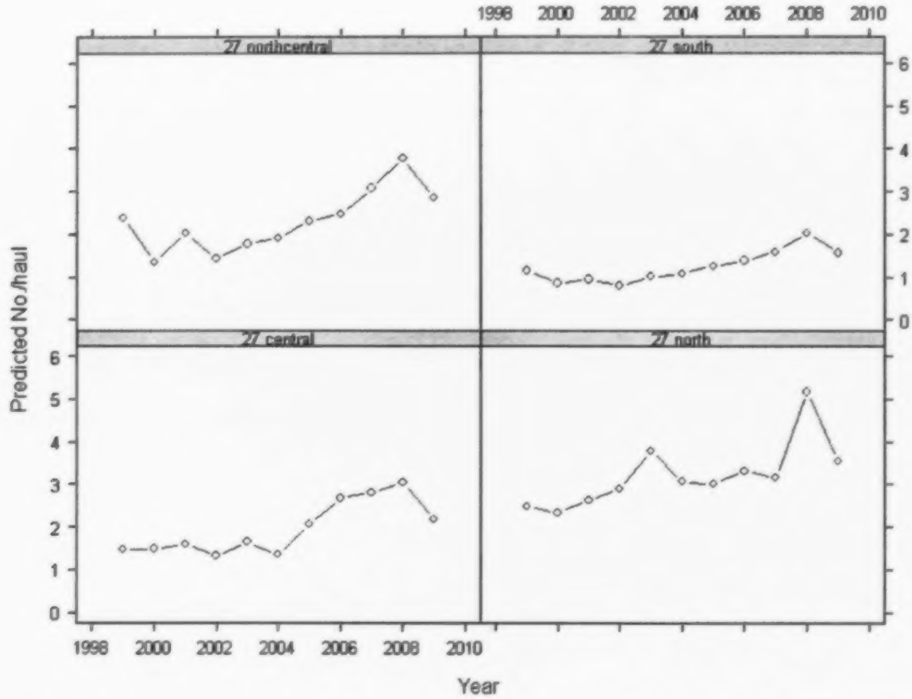


***Figure 5.18** – CPUE index of sublegal sizes from mixed-effects model of FSRS recruitment trap data. Annual index is estimated for week=9.*

6. INDICATORS OF RECRUITMENT AND REPRODUCTION FROM COMMERCIAL CATCH SAMPLES

6.1. INTRODUCTION

As in most lobster fisheries, there are no direct measurements of egg production. A potential indicator of production includes the abundance of ovigerous females, mature females and multiparous females. Ovigerous females can be measure through at- sea samples as they are easy to identify and record. However their numbers can be biased by a number of factors including differences in catchability and distribution to nonovigerous animals targeted by fishermen who may avoid areas with higher catches of ovigerous animals. As the ovigerous females are not landed, they represent an increasing proportion of the catch as the season progresses as the non ovigerous females and males are removed from the population. Thus the removal rate of these other lobsters could also influence the catch rates of ovigerous females later in the season.

Another potential indicator is the proportion of mature sized females, however these cannot be directly identified at sea and the estimate would be based on application of a maturity ogive to the size frequency from a port or at-sea samples. The proportion of mature females could give a better indication of egg production if the fishing fleet actively avoids areas with large numbers of ovigerous females, or the ovigerous females have a different catchability and distribution. Another advantage would be the ability to develop an indicator based on port samples and reduce the need for more expensive at- sea sampling.

The proportion of multiparous females is another indication of the health of the breeding population as they provide increased egg production and reduce the dependency on first time breeders adding great stability to the population. Mature females can reproduce every second year, with larger sizes (>120 or 130mm CL) producing multiple broods from a single mating and, thus, two sets of eggs in a three year period.

With the present development of more accurate maturity estimates it will be possible in future assessments to apply these to the sizes frequencies and obtain estimates of the proportion mature and proportion multiparous in the catch and develop an indictor for monitoring the health of the reproductive portion of the population.

An index of egg production could be developed based on the number of eggs observed in the traps. This could be estimated from the numbers of ovigerous females in the at-sea samples expanded by a measure of abundance to give an estimate of the ovigerous females caught at size which can then be multiplied by the fecundity at size relationship to give an estimate of egg numbers. At this stage, landings were used as the measure of abundance and it is assumed that they reflect the population. However, as stated earlier many factors can influence landings and as other measures of abundance are developed (i.e. catch rates) they could be substituted.

As ovigerous females are thrown back and thus can be caught more than once, they are at best an indicator of the number of eggs. This index suffers from the problems stated above for percentages of ovigerous and catch rates of ovigerous females, but offers the benefit of being weighted by landings over the season and accounting for the increase in fecundity with female size.

A disadvantage is that extensive at sea sampling may be needed over the season to give an accurate indictor of abundance. However in areas with window or maximum size protection, at-

sea samples may already be required as they may represent the best method of obtaining precise estimates of the proportion of the population in these protected sizes.

6.2. METHOD

6.2.1. Ovigerous Female Catch Rate

At sea samples were taken in Little River 1989-2010 with trap information allowing for the calculation of catch rate information. In this analysis total numbers of ovigerous females were divided by total traps sample. Samples were not taken at the same time every year so samples were pooled by months, with May representing the first quarter of the season, June the middle two quarters and July the last quarter

6.2.2. Egg Index

Landings and at sea samples were assigned to log grid areas where grids information existed. Where no grid information existed, landings were assigned to the grids based on the port of landing. Landings and at sea samples were pooled by month (May/June).

Using the method used previously in LFA 34 2006 assessment, the sea sample was converted to estimated weight at size based on the following length weight relationship.

$$Wt\ (gms) = a \times CL^{b}$$

	a	b
Male	0.000608	3.0583
Female	0.001413	2.8746
Ovigerous	0.004820	2.6380

The size frequency was expanded by the ratio of the weight of the legal catch in the sample and the landed catch to give an estimate of weight at size for each grid area and month. Weight at size was converted back to number at size using the length weight relationship. The numbers at size for each month and grid were combined to give an estimate of the numbers landed at size in the LFA.

Ovigerous female numbers were converted to number of eggs based on the Length Fecundity relationship.

$$Egg\ Number = a \times CL^{b}$$

a	b
.00256	3.4090

The Egg Index was the total number of eggs x 10^{-6}.

6.3. RESULTS AND DISCUSSION

6.3.1. Ovigerous Female Catch Rate (LFA 27)

Little River ovigerous female catch rates are presented in Tables 6.1 and Figure 6.1. The data shows an increasing catch rate of ovigerous females from May to July, a trend that has been demonstrated for several fishing grounds with spring fishing seasons (Tremblay and Lanteigne, 2005). The increase in ovigerous female catch rate could be due to increased catchability due to the removal of legal size animals, changes in ovigerous female behaviour or distribution, females extruding new eggs later in the season and increased water temperatures.

Both the May and June period show increased catch rates in recent years which is consistent with the overall increase in landings and to management changes that have increased the minimum legal size allowing more females to reproduce and become ovigerous.

Where a time series of at sea samples exists the catch rate of ovigerous females could provide a useful tool in determining the health of the reproductive capacity. The CPUE could be converted to units of eggs with fecundity data. The major draw back is the cost of an at sea sampling program and the need for consistent sampling over time. If resource were available specific areas within selected LFAs could be sampled to provide an index of ovigerous females.

6.3.2. Egg Index (LFA 31a)

The Egg Index results are summarized in Table 6.2 and values plotted against landings in Figure 6.2.

Figure 6.3 shows the breakdown of the Egg Index by size groups Sublegal, Legal and the window size (114-124mm CL) with cumulative egg numbers at size plotted as number and percentage. (Figure 6.4)

In the most recent years (2008-2010) there has been a dramatic increase in the overall number of eggs and proposition of the eggs originating from the smaller sizes. The proportion of eggs originating from sub legal sizes has increased even though the minimum legal size has decreased over this time. The increases observed are the result of a large recruitment pulse that began in 2005 and has seen landings increase five fold.

The changes in numbers in the legal sized catch are given in Figure 6.5 and for all size of ovigerous females in Figure 6.6.

The numbers of lobsters and resultant eggs, from the window size females has remained relatively constant and represent a lower proportion than in 2002-03. It takes 5-7 years for newly recruited female lobsters to grow to the window size range so to date few of the animals from the recent recruitment pulse would have reached that size, however some increase would be expected as the window size was established prior to 2000.

An index of egg production is possible from at-sea samples or could be developed through a fishery independent trap survey as is done in the Western Australian Rock lobster fishery (Caputi et al. 2008). An advantage of an egg index over an index based on ovigerous females is that it takes into account that fecundity increases with size. This may be of special importance in LFAs with measures to protect larger sizes (LFA 31a Window size, LFA 30 Maximum size).

6.4. SUMMARY

Two approaches for developing indicators of reproduction are illustrated. The first is from the CPUE of ovigerous females. In this case sampling must cover a substantial portion of the season because the CPUE of ovigerous females typically increases over the season in spring fisheries. For the port of Little River in LFA 27, CPUE of ovigerous females has increased since about 2003, coincident with increases in the minimum legal size which allowed more females to extrude eggs before being captured by the fishery.

The second approach is to develop an egg index by expanding the size composition from at-sea samples to the fishery from an abundance index and using the length-fecundity relationship to

estimate the total number of eggs. This approach currently uses landings for the abundance index but other abundance indices could be employed. The egg index is developed for LFA 31a and like landings, was substantially higher in more recent years compared to 2002-2003.

6.5. TABLES

***Table 6.1** – Monthly mean catch rate of ovigerous females in at-sea samples from Little River (LFA 27) 1990-2010.*

Year	May				June				July				Total			
	Mean CPUE	SD CPUE	No. of Samples	No. of TH	Mean CPUE	SD CPUE	No. of Samples	No. of TH	Mean CPUE	SD CPUE	No. of Samples	No. of TH	Mean CPUE	SD CPUE	No. of Samples	No. of TH
1990					0.32		1	60	0.07		1	217	0.20	0.17	2	277
1994	0.06	0.02	3	772	0.09	0.05	13	3422	0.33	0.13	5	1298	0.14	0.13	21	5492
1995	0.04	0.01	2	519					0.67		1	249	0.25	0.37	3	768
1997	0.04		1	246					0.15		1	247	0.09	0.08	2	493
1999					0.19	0.07	6	1360	0.32	0.25	3	565	0.23	0.15	9	1925
2000	0.16	0.05	6	1663	0.15	0.01	2	499	0.60	0.17	4	984	0.31	0.24	12	3146
2001	0.15	0.17	2	605	0.16	0.13	5	1125	0.40	0.17	2	547	0.21	0.17	9	2277
2002	0.14	0.05	4	968	0.23	0.13	4	1127	0.47		1	238	0.22	0.13	9	2333
2003	0.11	0.03	3	882	0.19	0.09	4	901	0.42	0.07	2	420	0.21	0.14	9	2203
2004	0.18	0.02	2	606	0.26	0.10	5	1270	0.88		1	280	0.32	0.24	8	2156
2005	0.12	0.02	2	471	0.22	0.02	2	251	0.36	0.03	2	398	0.23	0.11	6	1120
2007	0.40		1	83	0.52	0.05	2	283	0.47	0.06	2	488	0.48	0.07	5	854
2009					0.33	0.09	7	1057	0.48	0.02	3	580	0.38	0.11	10	1637
2010	0.54		1	68	1.32	0.34	3	170	1.44		1	50	1.19	0.43	5	288

***Table 6.2** – Egg Index and landings LFA 31a*

Year	Landings (kg)	Egg Index Total	Egg Index Sublegal	Egg Index Legal	Egg Index Window	% eggs sublegal	%eggs Legal	% eggs Window	% Lobsters in window size
2002	101,654	299	35	224	40	12%	75%	13%	11.1%
2003	153,859	462	44	356	62	10%	77%	13%	9.5%
2004	216,141								
2005	423,826								
2006	661,246								
2007	799,296								
2008	926,496	2639	966	1648	24	37%	62%	1%	0.5%
2009	951,561	2812	1136	1633	42	40%	58%	1%	0.8%
2010	862,870	4035	1580	2402	52	39%	60%	1%	0.5%

6.6. FIGURES

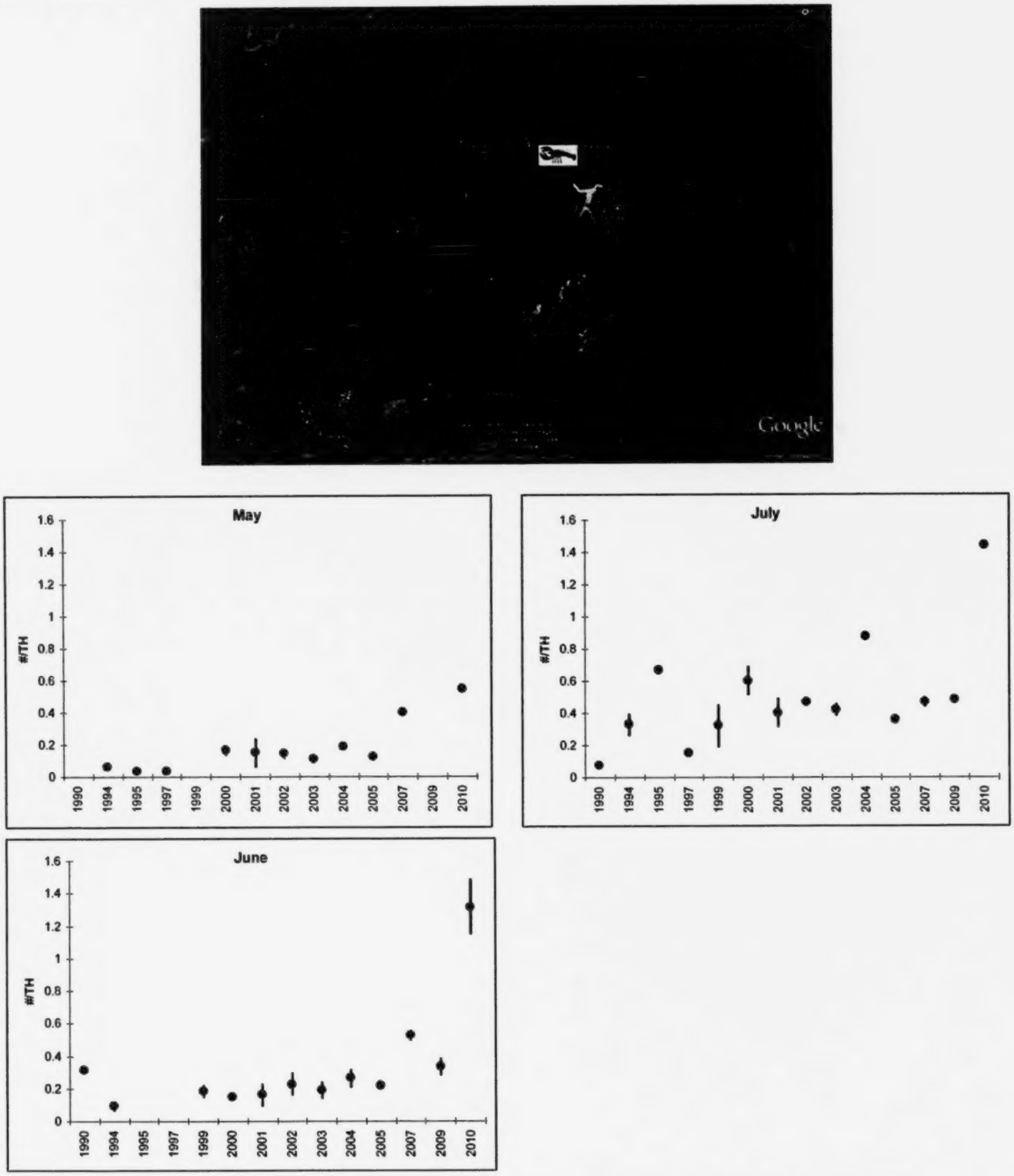


***Figure 6.1** – Mean and Standard Deviation CPUE (#/TH) of ovigerous females in at sea samples taken in Little River (LFA 27).*

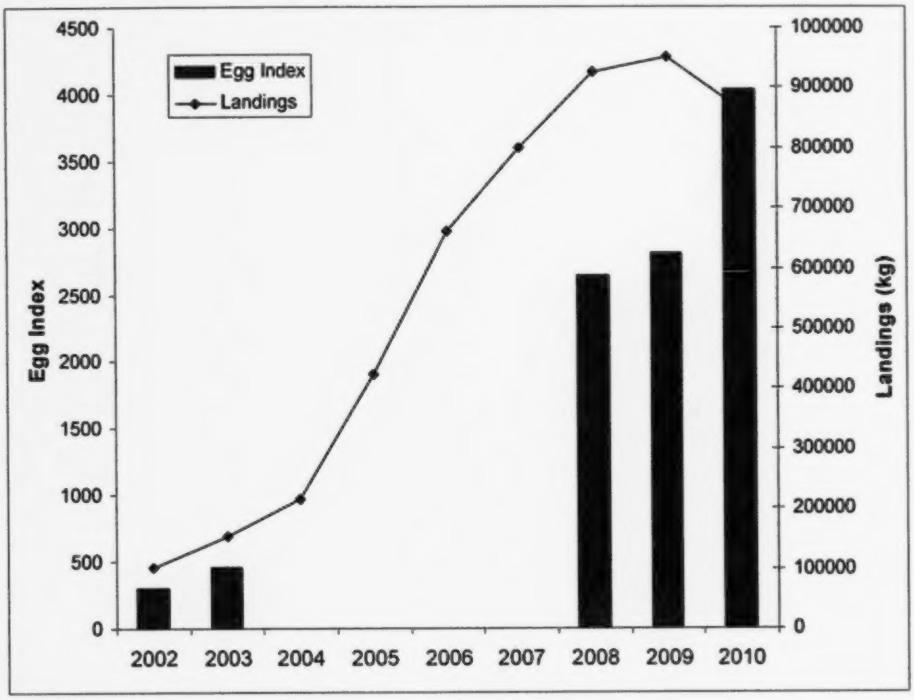


Figure 6.2 *– Egg Index and landings for LFA 31a 2002, 2003, 2008, 2009, 2010.*

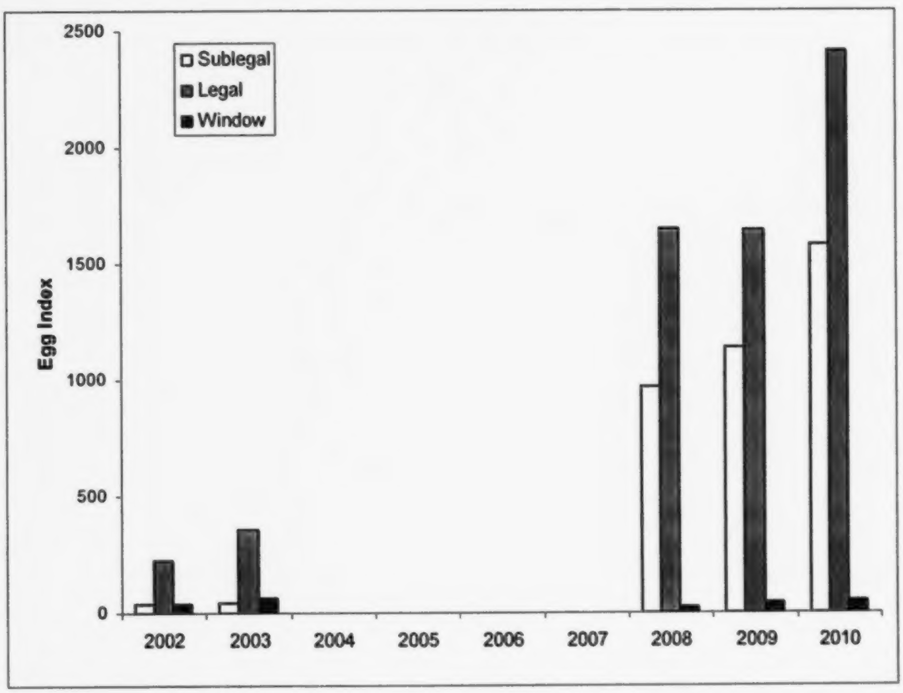


Figure 6.3 *– Egg Index values by size categories : Sublegal sizes (86mm CL 2002, 84mm CL 2003, 82.5mm CL 2008-10), Window size (114-124mm CL).*

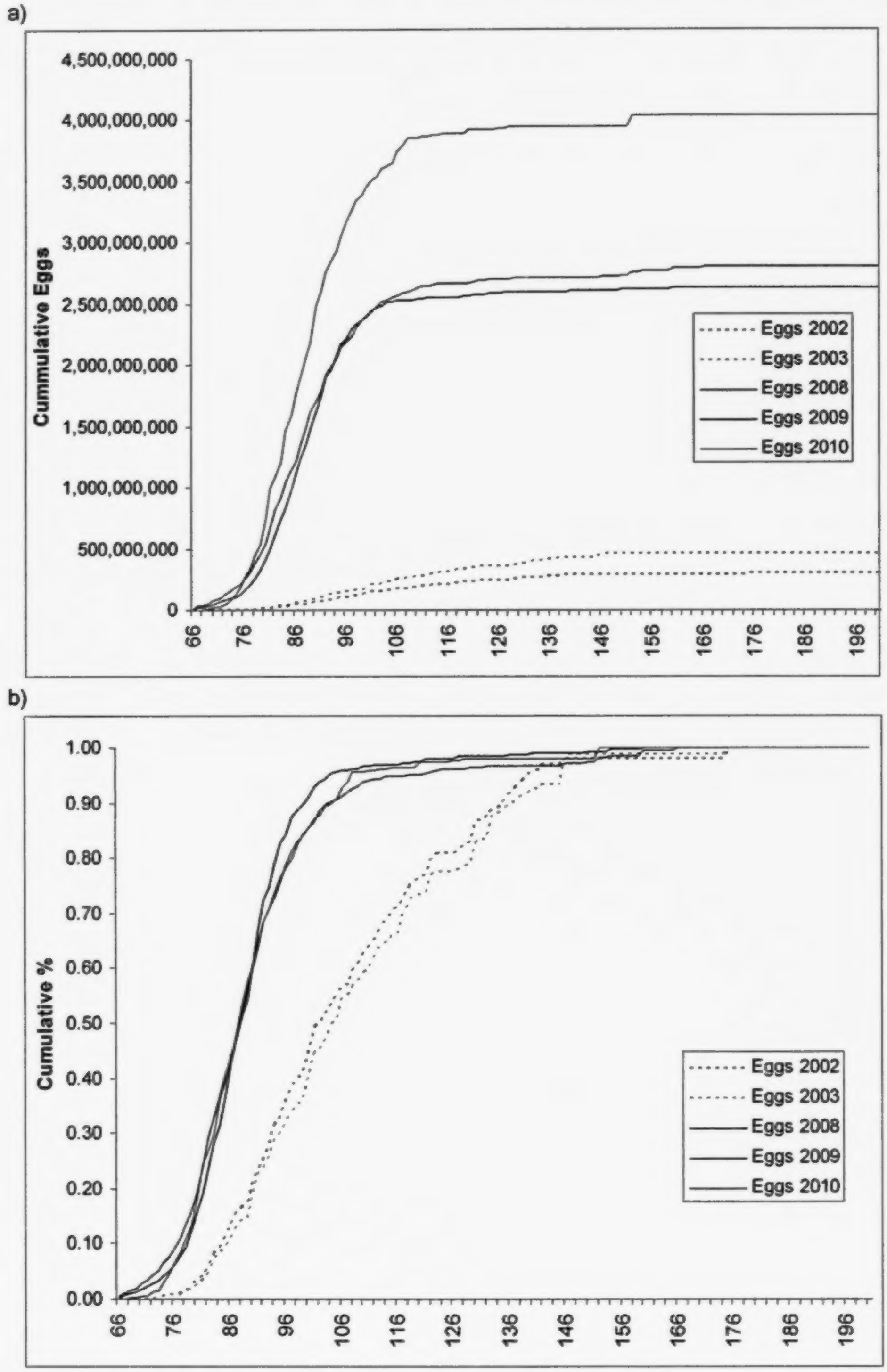
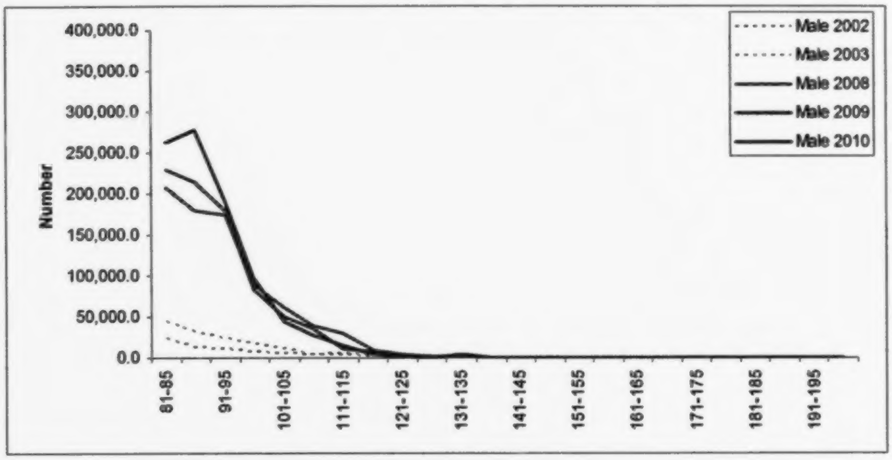
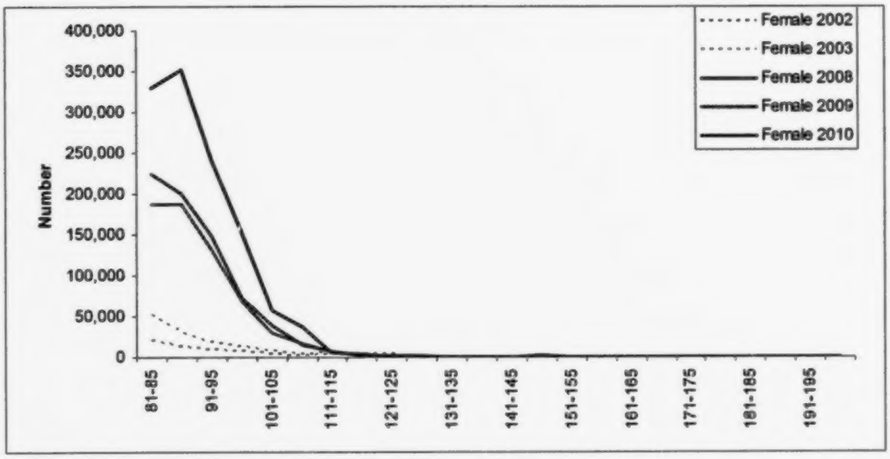


***Figure 6.4** – Cumulative egg number at size a) numbers, b) percentage.*

a)



b)



c)

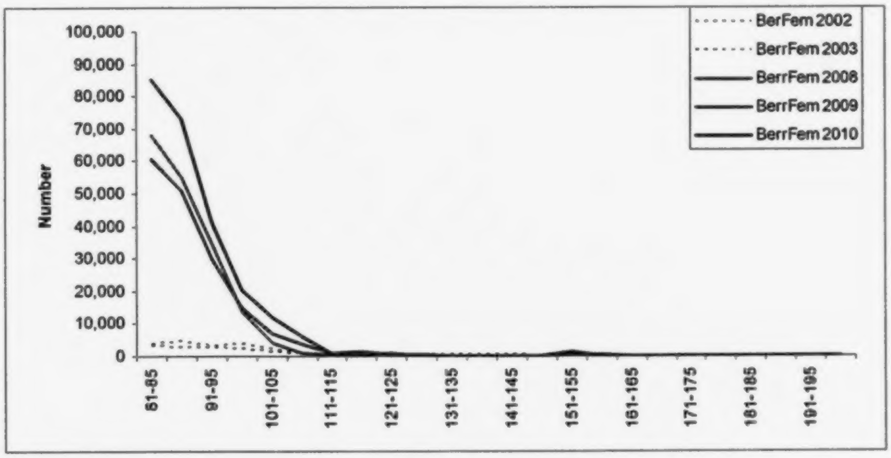


***Figure 6.5** – Estimated number at size LFA 31a 2002, 2003, 2008, 2009, 2010. a) Males, b) Females, c) Ovigerous females.*

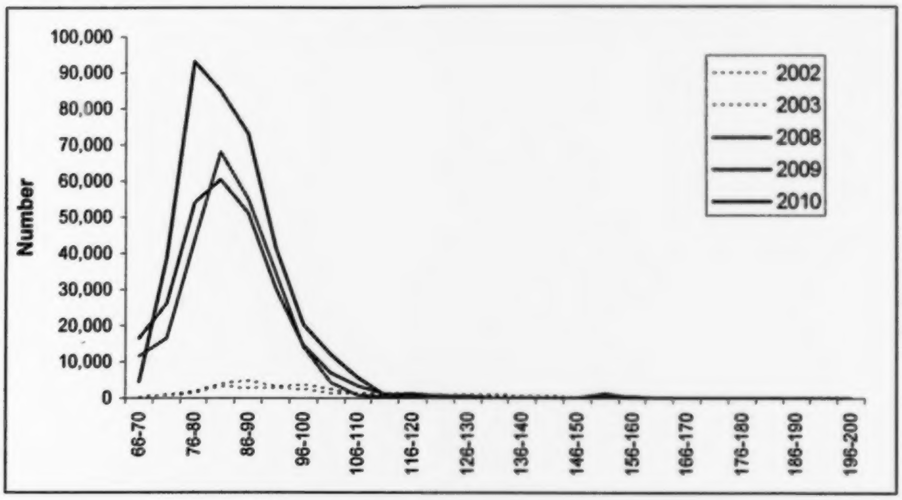


Figure 6.6 – Estimated number of ovigerous females at size LFA 31a 2002, 2003, 2008, 2009, 2010.

7. INDICATORS OF FISHING PRESSURE - CATCH SAMPLES

7.1. INTRODUCTION

Previous assessments have used length based method to estimate exploitation rates (e.g, Pezzack et al. 2006, Tremblay and Reeves 2004), including the a Length Cohort Analysis (Cadrin and Estrella 1996) and various other methods that compare ratio of numbers in the recruit size range and those in the subsequent molt stage (recruit +1)

However certain assumptions must be met if these size based methods are to be used. These include (i) that the measured size structure is representative of the trap catch; (ii) that recruitment is constant; (iii) that there is no emigration of lobsters from the area as they increase in size; (iv) that both fishing and natural mortality is not size dependent and variable across years and (v) that the minimum legal size is constant. If the above assumptions are reasonably met, then as exploitation increases, the proportion of smaller sizes increases.

In recent years the LFA 27-33 fisheries has experienced large and often unprecedented increases in landings believed due to a change in recruitment level. Such large changes in recruitment violate the second assumption making use of size based methods of questionable value.

7.2. METHODS, RESULTS AND DISCUSSION

A simple indicator of changes in the size structure that has been used in the past, is the percentage of the catch in the first moult group. Based on growth rate studies the carapace length increases between 10-15 % depending upon sex and maturity. Lobster in the first 12 mm above minimum legal size will in large part be newly recruited animals or ovigerous females which mated the previous year and extruded eggs rather than moulting.

The proportion of lobsters in the first moult group as determined from port samples of legal sized lobsters are given in Figure 7.1 and compared with landing trends in Figure 7.2. The percentage in the first moult group has increased during periods of increased landings and has been lower during periods of more stable landings. While it is believed that these increases in the percentage in the first moult group are most likely due to increased recruitment, this simple indicator is not able to separate the effects of changes in exploitation rates and recruitment.

As the fishery is heavily based on new recruits, the median size as measured in port samples will also be affected by both changes in recruitment and exploitation. Mean and median sizes are presented in Figures 7.3 and 7.4, showing the expected decrease in the median size during periods of increased landings. The exception is LFA 27 but here the increases in median size are related to a series of increases in the minimum legal size.

During periods of rapid changes in recruitment levels the usefulness of the size based methods for assessing fishing pressure and exploitation rate is greatly reduced. More robust methods based on catch rate data are now available and should be used.

Although the value of collecting length-data from commercial catches for measuring fishing pressure is low, length data has value for characterizing the fishery and possibly the population structure. In addition commercial size data can be useful in measuring the response to management changes such as increases in the minimum legal size.

7.3. SUMMARY

The size structure of lobster stocks in LFA 27 and other areas where recruitment has fluctuated has low value for evaluating fishing pressure. Changes in size in the fished population can arise from changes in fishing pressure, but these changes cannot be separated from other possible causes.

7.4. TABLES

Table 7.1 *Summary of size data (CL mm) from port samples: Mean, Median, Minimum and Maximum sizes LFA 27, 29, 31, 32, 33.*

LFA 27

Year	Count	Mean	Median	Min	Max
1990	3063	81.2811	80	67	150
1991	3712	84.5348	83	69	148
1992					
1993	108	95.1574	92	80	132
1994	449	81.1136	80	70	117
1995	1131	91.5756	88	70	146
1996	13373	80.8807	79	69	160
1997	10937	80.9156	79	68	160
1998	9633	81.8952	80	66	148
1999	9679	82.8122	80	71	170
2000	9543	82.4844	81	72	172
2001	8140	84.0618	82	72	160
2002	4243	85.3448	83	73	170
2003	5066	85.303	83	74	161
2004	3112	85.6398	83	73	167
2005	1689	84.6448	83	74	149
2006					
2007	2276	84.3937	83	75	148
2008	4343	86.9963	85	77	160
2009	4131	87.7463	86	77	173

LFA 29

Year	Count	Mean	Median	Min	Max
1990	873	92.3	90	81	141
1991	869	93.4	90	80	164
1992	352	93.3	90	80	149
1993	1509	95.8	92	79	173
1994	2313	97.8	93	79	164
1995	1126	99.4	92	80	177
1996	1649	98.7	92	78	175
1997	1407	97.1	91	79	184
1998	7164	100.1	95	78	171
1999	1326	102.1	95	82	194
2000	4044	97.7	94	77	182
2001	1395	97.7	94	80	168
2002	1168	97.3	94	79	167
2003	1763	93.8	91	80	170
2004	1510	91.0	89	82	148
2005	1027	91.7	90	83	172
2006					
2007	519	96.5	95	84	155
2008	552	96.5	94	81	139
2009	2590	95.1	93	82	151

LFA 31

Year	Count	Mean	Median	Min	Max
1990	1363	93.7	91	80	170
1991	1113	94.9	92	80	158
1992	1057	95.5	92	80	165
1993	1287	94.6	92	79	169
1994	1375	94.8	92	80	180
1995					
1996	1406	94.5	91	80	182
1997					
1998	1913	98.5	94	80	173
1999	1523	98.7	94	82	158
2000	1770	95.9	93	81	150
2001	1846	95.0	93	81	160
2002	2506	98.0	95	81	169
2003	2612	98.4	95	81	182
2004	3219	93.9	90	81	195
2005	2430	91.5	90	81	179
2006	3585	92.0	90	80	155
2007	1085	92.6	91	83	134
2008					
2009	439	90.0	88	80	150

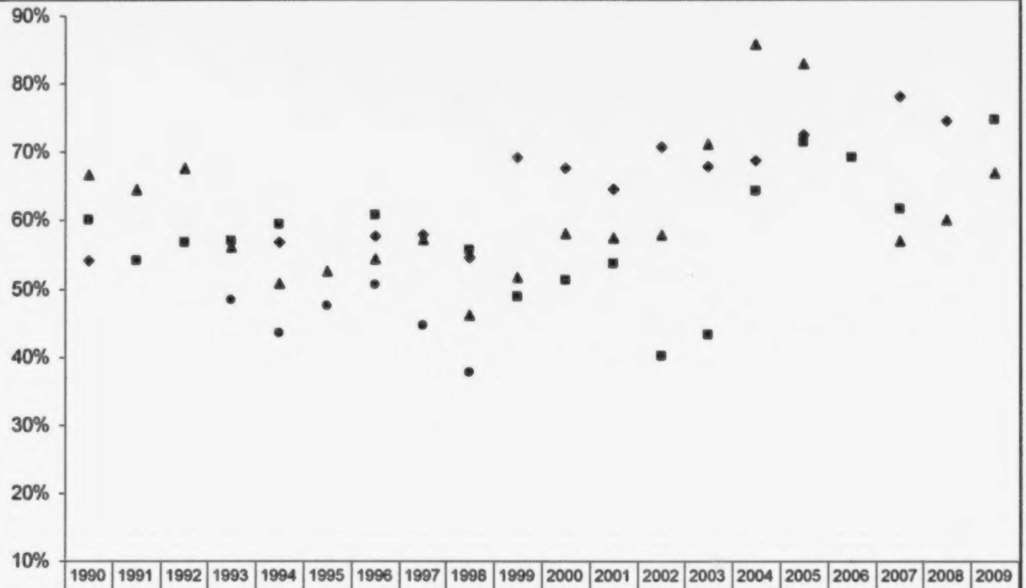
LFA 32

Year	Count	Mean	Median	Min	Max
1990	692	91.6	90	80	146
1991	516	95.6	93	81	165
1992	534	93.3	90	80	171
1993	710	93.0	91	80	163
1994	711	91.1	89	80	174
1995	229	89.5	88	80	140
1996	641	92.5	90	80	162
1997					
1998	597	92.6	90	81	180
1999	1296	97.3	94	81	170
2000	1696	96.0	93	81	161
2001	1387	93.1	91	82	161
2002	1532	94.9	92	80	152
2003	1554	95.5	92	81	161
2004	1199	95.9	92	81	158
2005					
2006	356	100.1	94	82	149
2007	631	91.3	90	82	127
2008					
2009					

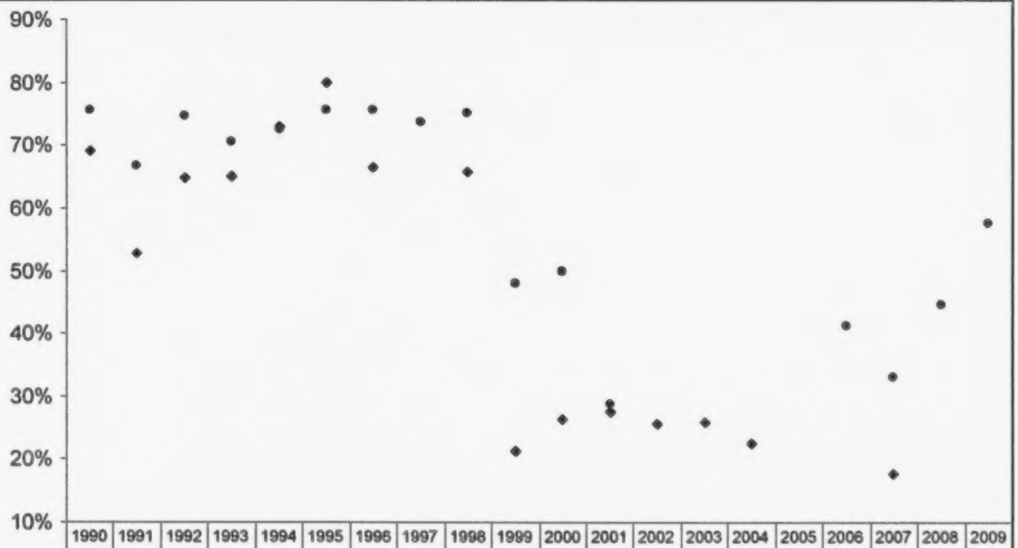
LFA 33

Year	Count	Mean	Median	Min	Max
1990	2551	90.3	89	80	139
1991	2774	92.6	89	80	171
1992	3374	90.4	88	80	138
1993	2949	91.2	89	57	139
1994	2781	91.2	89	80	138
1995	3340	90.4	88.5	80	156
1996	3411	90.5	88	80	161
1997	3798	90.5	89	77	182
1998	5368	90.6	88	78	172
1999	3961	91.2	89	75	170
2000	4153	91.9	90	79	153
2001	1679	94.5	92	81	155
2002					
2003					
2004					
2005					
2006	2489	91.4	90	81	146
2007	1350	90.1	89	82	146
2008	2671	90.8	89	81	147
2009	6169	91.1	90	80	165

7.5. FIGURES



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
◆ LFA27	54%				57%	0%	58%	58%	55%	69%	68%	65%	71%	68%	69%	73%		78%	75%	
▲ LFA29	67%	65%	68%	56%	51%	53%	54%	57%	46%	52%	58%	58%	58%	71%	86%	83%		57%	60%	67%
● LFA30				48%	44%	47%	51%	45%	38%											
■ LFA31	60%	54%	57%	57%	59%		61%		56%	49%	51%	54%	40%	43%	64%	71%	69%	62%		75%



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
◆ LFA32	69%	53%	65%	65%	73%	80%	66%		66%	21%	26%	28%	26%	26%	22%			18%		
● LFA33	76%	67%	75%	70%	72%	76%	76%	74%	75%	48%	50%	29%					41%	33%	45%	58%

***Figure 7.1** – Percentage of legal sized lobsters in the first moult group (Minimum size +11mm) from port samples.*

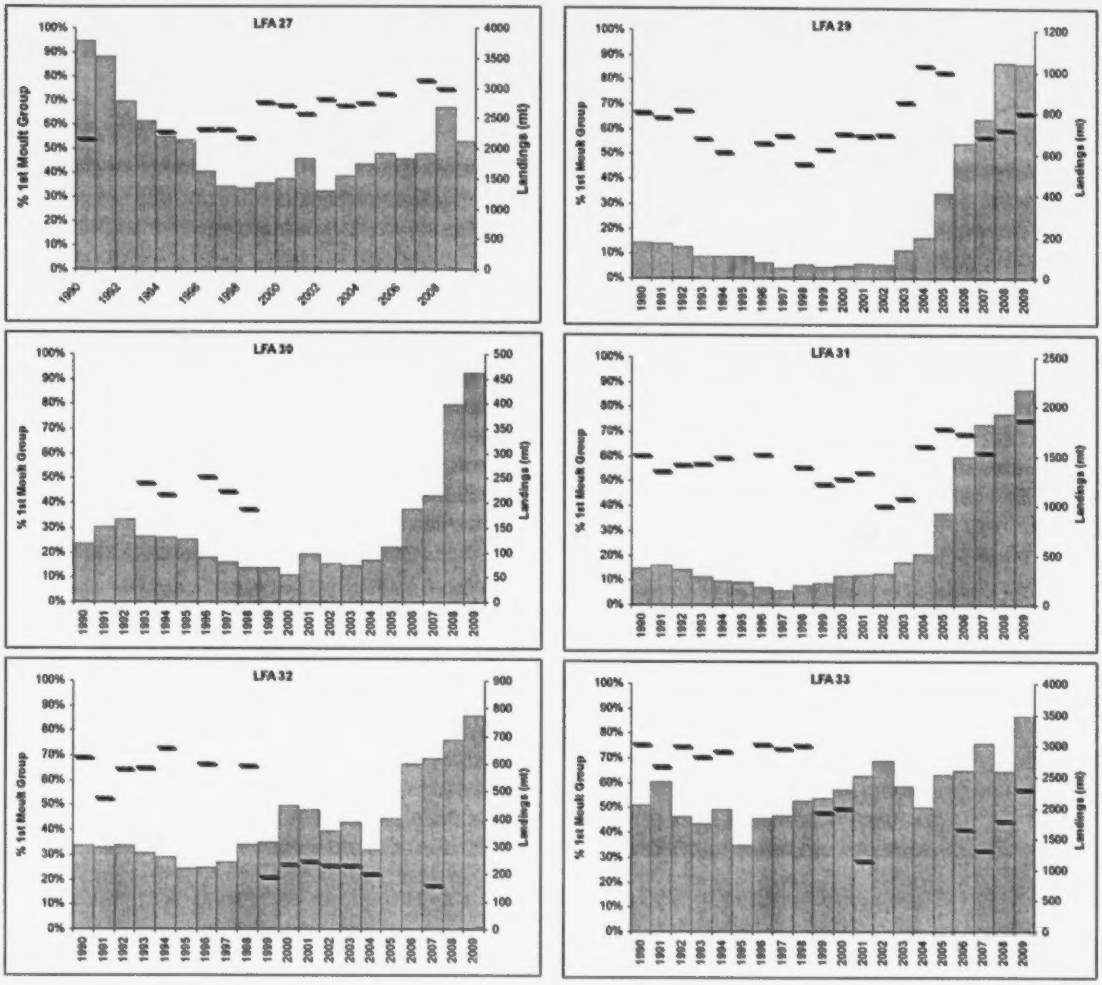
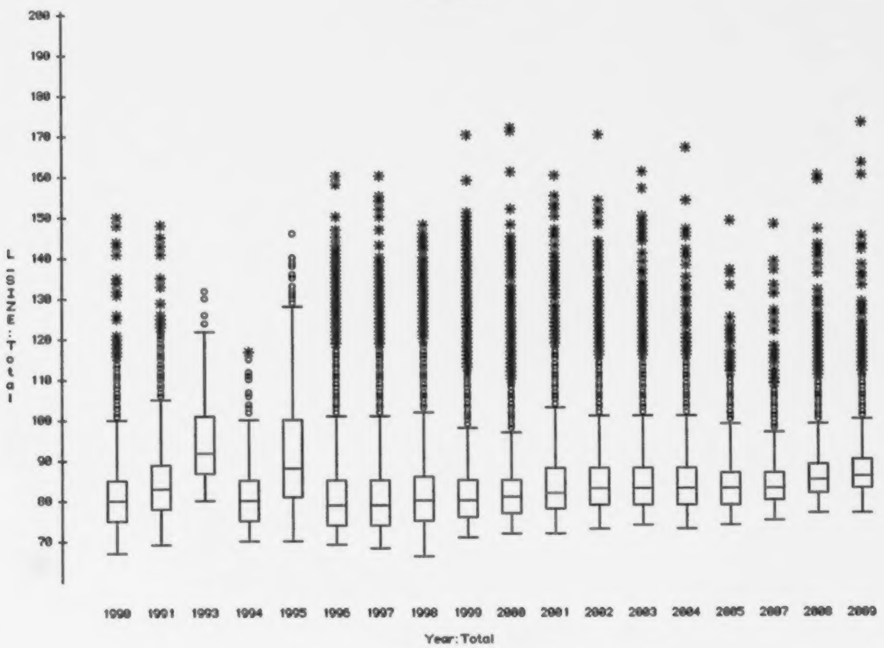


Figure 7.2 – Percentage of legal sized lobsters in the first moult group (Minimum size +11mm) from port samples and reported LFA landings (mt).

LFA 27



LFA29

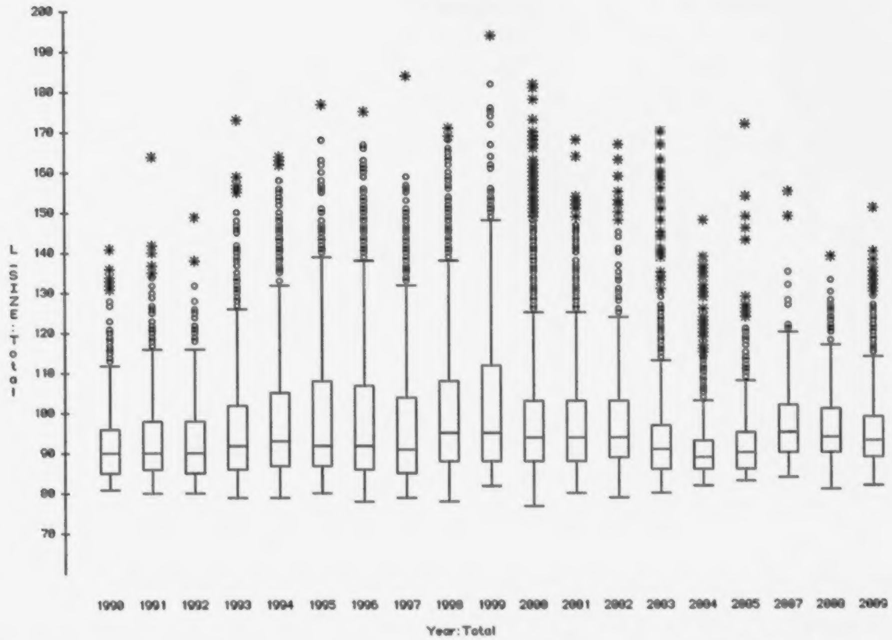
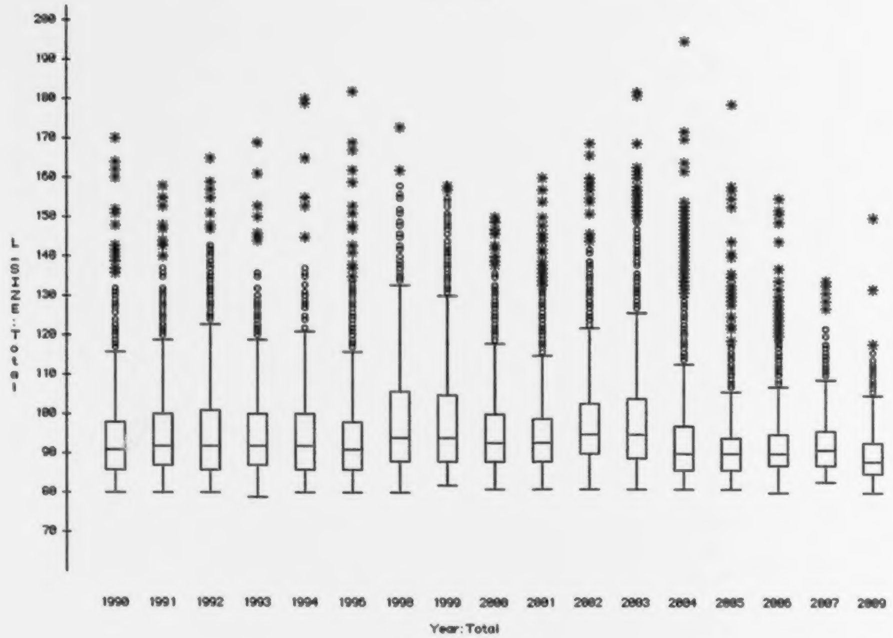


***Figure 7.3** – Box plots of port samples showing the median size (CL mm) LFA 27, 29.*
The box depicts the central half of the data roughly between the 25% and 75% points. The line across the box displays the median value. The whiskers extend from the top and the bottom of the box to depict the extent of the main body of the data. Extreme values are plotted with a circle. Very extreme data values are plotted with a starburst.

LFA 31



LFA 32

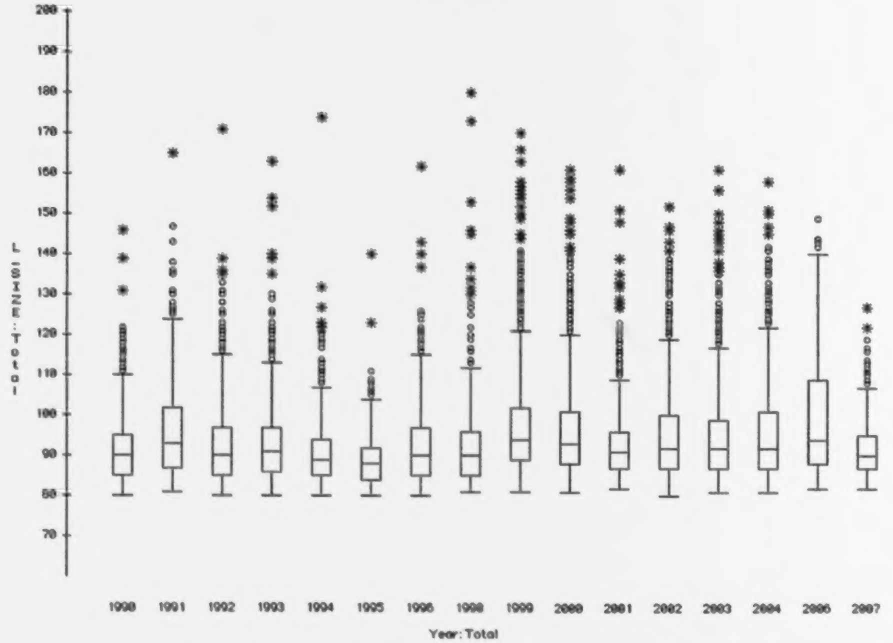


***Figure 7.3** – (continued) Box plots of port samples showing the median size (CL mm) LFA 31, 32.*
The box depicts the central half of the data roughly between the 25% and 75% points. The line across the box displays the median value. The whiskers extend from the top and the bottom of the box to depict the extent of the main body of the data. Extreme values are plotted with a circle. Very extreme data values are plotted with a starburst.

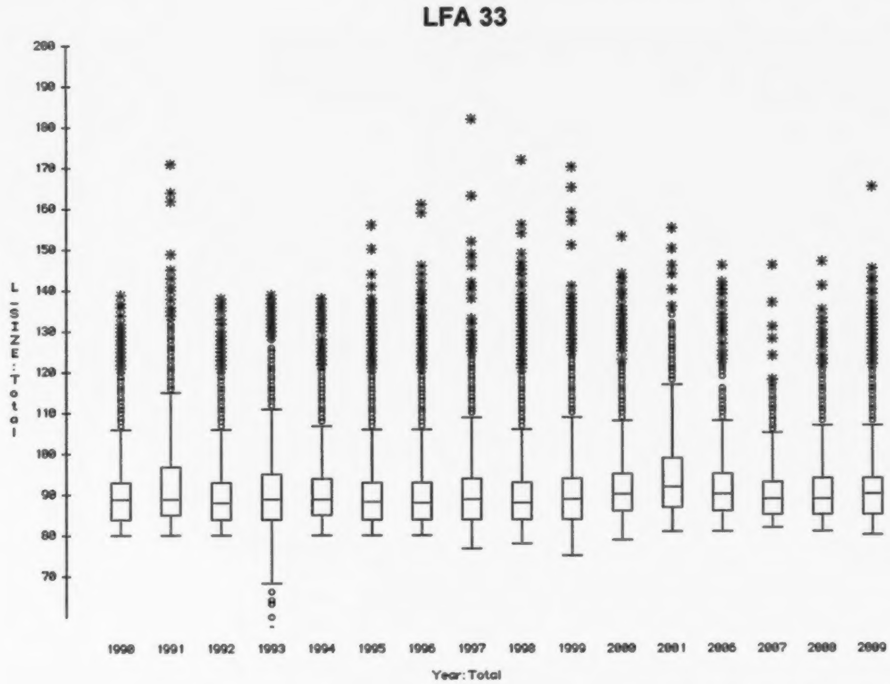


Figure 7.3 *– (continued) Box plots of port samples showing the median size (CL mm) LFA 33. The box depicts the central half of the data roughly between the 25% and 75% points. The line across the box displays the median value. The whiskers extend from the top and the bottom of the box to depict the extent of the main body of the data. Extreme values are plotted with a circle. Very extreme data values are plotted with a starburst.*

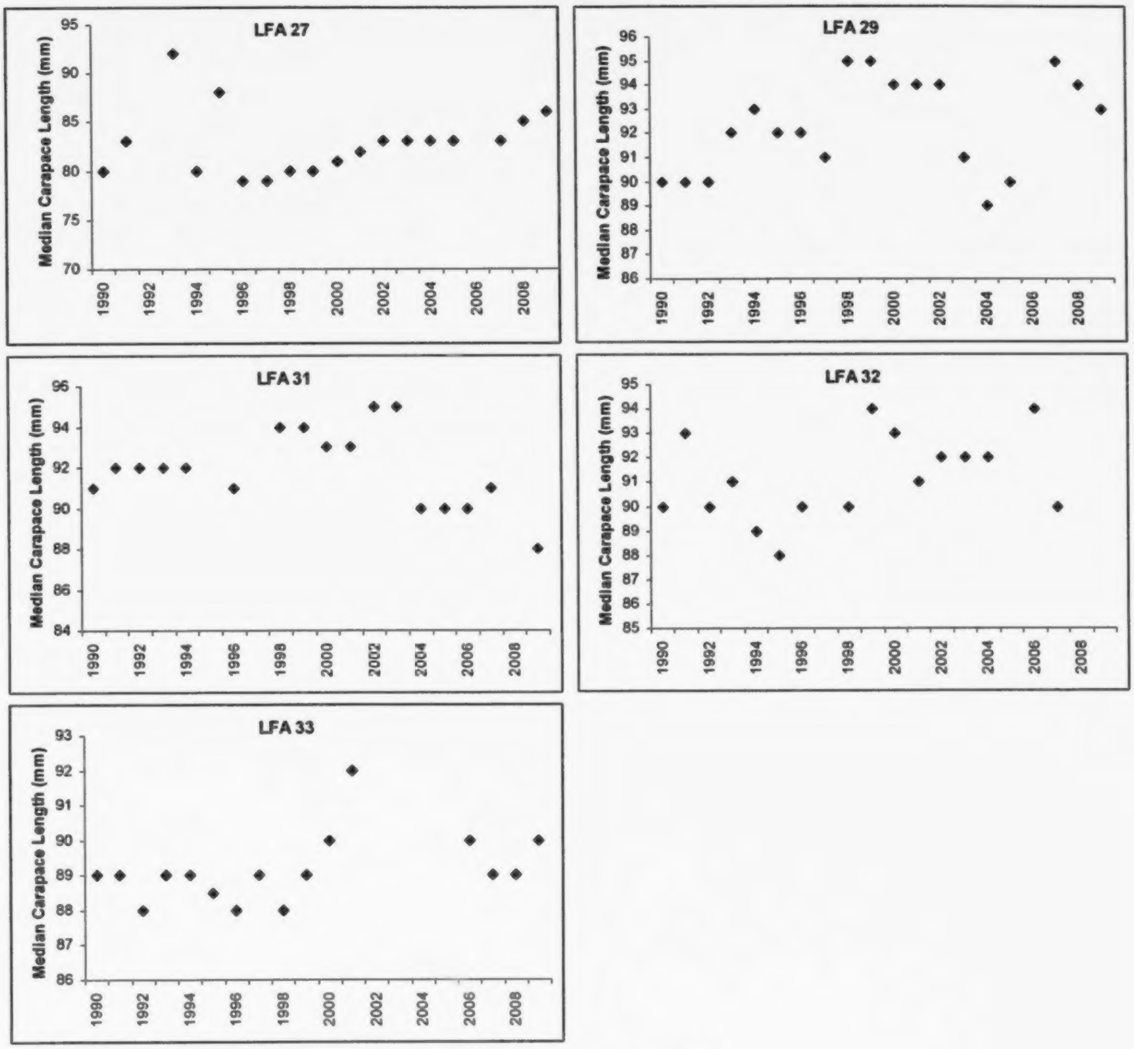


Figure 7.4 – Median sizes from port samples LFA 27, 29, 31, 32, 33.

8. INDICATORS OF FISHING CRESSURE – CONTINUOUS CHANGE-IN-RATIO (CCIR) EXPLOITATION RATE

8.1. INTRODUCTION

Here we use a change-in-ratio method developed by Claytor and Allard (2003) to estimate exploitation rate by length-class for selected stock assessment subunits. We refer to the method as CCIR. We examine some key assumptions, look at different types of estimates and at the variability associated with them.

8.2. METHODS

CCIR uses the within-season ratio of exploited size classes to unexploited size classes (actually exploited: exploited plus unexploited, see below). CCIR uses daily catches during the season (hence the "continuous" in Continuous Change-in-Ratio) rather than pre-season and post-season sampling. A major advantage of change-in-ratio methods is that they are not sensitive to annual variation in recruitment. This has been an issue with methods used previously such as Length composition analysis (e.g. Tremblay and Reeves 2004) and in light of some substantial increases in recruitment in recent years in LFAs 29-31 in particular, would be inappropriate to use.

Claytor and Allard (2003) recognized two types of exploitation. The usual or strict method considers only the exploited population and is defined as $\mu = C/N$ where C is the catch in numbers by the fishery, and N is the number of lobsters in the exploitable population (i.e. the legally harvestable portion of the stock) at the start of the fishing season. When the size of the exploited population changes over several years because of an increase in MLS, it is difficult to compare traditional exploitation estimates across years. For this reason the extended exploitation rate was defined by Claytor and Allard (2003) as $\mu^* = C/(N + N^*)$ where N^* is the number of lobsters in some unexploited size class. This allows a consistent base population across years, regardless of changes in the regulations. The CCIR method was used to estimate extended exploitation for size groups affected by the MLS changes.

The CCIR application here (and the original by Claytor and Allard) uses the FSRS trap catch rates and size classes. The estimates presented here are based on the FSRS recruitment trap project (Tremblay et al. 2009). Size classes used in the project are as below:

***Text Table 8.1** – Size groupings used in FSRS recruitment trap project.*

FSRS defined 1999 - 2003

size class	mm
1	< 51
2	51-60.9
3	61-70.9
4	71-75.9
5	76-80.9
6	81-90.9
7	91-100.9
8	>100

FSRS defined 2004 - present

size	mm
1	<11
2	11-20.9
3	21-30.9
4	31-40.9
5	41-50.9
6	51-60.9
7	61-70.9
8	71-75.9
9	76-80.9
10	81-90.9
11	91-100.9
12	101-110.9
13	111-120.9
14	121-130.9
15	>130

Fundamentally, CCIR models p^ (exploited class / (exploited class + reference class)) on cumulative catch over the fishing season to estimate exploitation rate. The data source for the estimates was the daily catches of lobsters in the FSRS recruitment project traps.

For most cases we estimate the "strict" exploitation rate described in Claytor & Allard (2003). For LFA 27 where there has been a significant increase in minimum legal size, we also estimate the "extended" exploitation rate.

It is important to note that the CCIR estimates are best thought of as an index of exploitation and likely give upper bounds for exploitation rates. They estimate the removals from the harvestable population only. Mature females move in and out of the exploitable population since they are protected when ovigerous. As such the ovigerous females are not accounted for. Animals in closed size windows such as exist in LFA 31A are also not accounted.

Assumptions

The assumptions of the analysis are that (1) the population is closed, (2) that the ratio of catchability between the classes is constant throughout the season for all traps, (3) that the ratio of catchability by the monitoring traps and by the commercial traps is constant over the season for all classes and (4) that the ratio of the fleet effort to the monitoring trap effort is either constant over the season or can be estimated up to a constant factor.

With regard to the assumption of a closed population (assumption 1), this is reasonable for 9 week seasons and where tagging studies have not indicated significant exchange of lobsters between fishing grounds (Tremblay et al. 1998). Assumption 1 may be problematic where larger lobsters become more available later in the season either because of movement onto the fishable bottom or because of increased q. If either of these occurs they would tend to bias the estimates downward.

Assumption 2 is potentially most problematic as changes in catchability with size and agonistic interactions around traps suggest larger lobsters may inhibit smaller lobsters from entry. As long as the catchability ratio remains constant this is not a problem for the method but if the decline in legal sizes causes increased catchability of sublegal lobsters, this would bias the CCIR estimates upwards.

Other investigators have reported negative correlations between large and small lobsters in traps. For example in rock lobster trap catches, catch rates of large (> 109 and > 140 mm CL) lobsters were negatively correlated with catch rates of smaller rock lobsters (< 90 and 81-100 mm) (Frusher and Hoenig, 2001; Ziegler et al. 2002). The assumption of a constant catchability ratio was addressed in Section 5.3.1 (catch rate model) and is revisited below (section 8.3.1).

Assumption 3 is reasonable in that some sizes no doubt have a different catchability in FSRS traps than commercial traps, but there is expectation that the ratio of the two should change over the season. Similarly it is not expected that the ratio of the number of FSRS trap hauls to the number of commercial trap hauls should change over the season (Assumption 4).

Changes in Minimum Legal Size

In LFA 27, the minimum legal size increased substantially from 1999-2009 (Text-Table 8.2). In addition the MLS increased from 70-73 mm CL in 1998 and 1999.

***Text Table 8.2** – Minimum legal size (MLS) by year in LFA 27.*

LFA	Year	MLS (mm)
27	1999	73
27	2000	73
27	2001	74.5
27	2002	76
27	2003	76
27	2004	76
27	2005	76
27	2006	76
27	2007	77.5
27	2008	79
27	2009	81

These MLS increases influence how the CCIR estimates are set up because the potential reference and exploitation size classes changed from 1999-2009.

We consider only those exploited sizes within 20 mm of the reference size class in order to reduce potential bias associated with catchability differences between size classes. We assume that the exploitation rate of these smaller exploited size classes is reflective of all exploited size classes.

For most assessment subunits we considered just 2 size exploitation types. As such there were generally 4 estimates of exploitation for any subunit: 2 size groups for each sex. For LFA 27 we consider 6 exploitation types because of the change in MLS over the period from 1999-2009. The exploitation types proposed for application to different assessment units and subunits are tabulated in the text table below:

***Text Table 8.3** – Types of exploitation rate by LFA and subunit. In all cases each type applied to males and females separately. All sizes are in mm. For LFA 33, season extends over 2 years. Convention is to make Year= 1st year of season e.g. 2007-08 season is 2007 year. *Extended estimate – exploited class includes some of the newly protected sizes to account for effect of increased minimum legal size. SD= statistical district. MLS = minimum legal size. Estimates for LFAs 30, 31b, 32 and 33 not presented in this document.*

Type	LFA	Subunits (SD)	Years applied	No. of estimates	Exploited class size	Ref class size
1√	27	N (1,4); S (6,7)	1999-2008	40	MLS-81	71-MLS
2√	27	N (1,4); S (6,7)	1999-2009	44	81-90	71-MLS
3√	27	N (1,4); S (6,7)	2002-2009	32	81-90	71-76
4√	27	N (1,4); S (6,7)	2007-2009	12	81-90	76-MLS
5√	27	N (1,4); S (6,7)	1999-2009	44	91-100	71-MLS
6*	27	combined	2007-2009	6	76-90	76-MLS
7	29		1999-2008		84-90	76-84
8	29		1999-2008		91-100	76-84
9	31a		1999-2009		MLS-90	76-MLS
10	31a				91-100	
11	33		1999-2008		82.5-90	76-82.5
12	33				91-100	
11	30				82.5-90	76-82.5
12	30				91-100	
11	31b				82.5-90	76-82.5
12	31b				91-100	
11	32				82.5-90	76-82.5
12	32				91-100	

Here we display the results for the LFA 27 unit, two subunits within the LFA 29-32 assessment unit, and one subunit within the LFA 33 unit.

All CCIR estimates were done in R using the package CCIR. This package was developed by J. Allard under contract to DFO.

8.3. CHANGE-IN-RATIO EXPLOITATION RATE: RESULTS AND DISCUSSION

8.3.1. LFA 27

Influence of Legal Size CPUE on Sublegal CPUE

This was considered in section 5. The daily CPUEs of sublegal lobsters increase over the season in some years (Fig. 5.3). If this increased CPUE of sublegals is due to increased catchability of this size group alone, the CCIR estimates will be biased upward. If both size groups have increased catchability of the same magnitude, the CCIR estimates should not be biased.

We would expect that if the catch rate of sublegals increased as result of the depletion of legals sizes, there would be a negative relationship between the catch rates of the two groups. This was seen by Frusher and Hoenig (2001) who examined the catch rates for small (< 90 mm CL) and large (> 109 mm CL) rock lobster (*Jasus edwardsii*). They reported "The correlation data demonstrated that if a large lobster is in a trap it is unlikely that there will be many small lobsters and vice versa. This negative correlation was strongest in regions where large lobsters were abundant".

The daily CPUEs of sublegal lobsters (all sizes) and legal lobsters (all sizes) of individual fishermen showed a weak positive relationship when all the data from 1999-2009 were plotted (Fig. 8.1). When broken out by year and statistical district, no consistent trend in slope was evident (as depicted by linear models fit to the data) (Fig. 8.2). The same result was obtained by Allard and Claytor (MS, in review): "A small positive trend was observed between the catch residuals and the number of smaller or larger non-egg-bearing lobsters caught, suggesting that agonistic behaviour, if present, does not reduce catchability".

The finding of a slight positive relationship between the catch rate of sublegals and legals is interpreted here as indicative of high day to day variability in CPUE, sometimes related to temperature variability (Drinkwater et al. 2006). The slight positive relationship may arise because when conditions are favorable for catching legals they are also favorable for catching sublegal sizes. The CCIR estimates use narrower size classes than those that pertain to the sublegal and legal catch rates plotted in Figures 8.1 and 8.2. We expect that the narrower size ranges have a low probability of being negatively correlated.

Exploitation Estimates

Results from some 174 individual estimates of exploitation rate for LFA 27 are presented; most are presented in figure form only. Some sets of estimates are detailed to provide examples. The high number of estimates results from multiple years, multiple "types" of exploitation rate (various combinations of exploited and reference classes), 2 sexes and 2 subunits. Examples of the details of the within-season estimates for one exploitation type and one year are shown in Appendix 5. These details show the seasonal decline in the catch of exploited classes relative to unexploited classes. Day to day variability was high but in most cases significant exploitation rate estimates (zero not included in confidence interval) were obtained.

Type 1 - Exploited class size MLS to 81 mm CL, ref class size 71 mm CL to MLS – Numbers of lobsters within the exploited and reference size groups exceeded 200 in 33/40 cases (10 yr for each of 2 subunits and 2 sexes - Table 8.1-8.4). Significant exploitation rates were obtained in all 40 cases. Confidence intervals were generally narrower for the northern subunit (Fig. 8.3), perhaps because sample sizes were higher.

Estimates were generally high (> 0.70) for males and females over the period 1999 to 2008. There was no clear trend in either of the subunits or sexes over the time period. The estimates for both males and females were higher in the northern subunit (mean=0.77) than in the southern subunit (mean=0.72).

Type 2 - Exploited size 81-90 mm CL, ref size 71 mm CL to MLS – Significant exploitation rates were obtained in all 44 cases (Fig. 8.4). Numbers of lobsters within the exploited and reference size groups exceeded 200 in 35/44 cases (11 yr for each of 2 subunits and 2 sexes - Table 8.5-8.8). Estimates for this size group were also high and again there was no clear trend over the period. Details and plots related to Type 2 exploitation estimates in 2002 are shown in Appendix 5.

Type 3 - Exploited size 81-90 mm CL, ref size 71-76 mm CL – Significant exploitation rates were obtained in all 32 cases (Fig. 8.5).

Type 4 - Exploited size 81-90 mm CL, ref size 76 mm CL to MLS – These estimates are available only for the last 3 years when the size increased from 76 mm CL to the current MLS of 81 mm CL. Significant exploitation rates were obtained in all 12 cases (Fig. 8.6). They all show a high point estimate in 2008.

Type 5 - Exploited size 91-100 mm CL, ref size 71 mm CL to MLS – All of these estimates had very wide confidence intervals (Fig. 8.7). Results were non-significant (confidence interval contained 0) in 6 of 44 cases; in an additional 7 cases the lower confidence interval was less than 0.2. These estimates are unlikely to be useful in the future. The numbers of lobsters in the 91-100 mm CL were low, averaged 91 (range: 11-214) over all years, sexes and subunits.

Type 6. Exploited size 76-90 mm CL, ref size 76 mm CL to MLS – Extended estimates were done for LFA 27 as a whole. Compared to Type 4 estimates they were markedly lower (average of 0.54 versus 0.75 for Type 4) and significantly so in 2008 and 2009 for both males and females (Fig. 8.8). These results indicate that increases in MLS resulted in a significant reduction in exploitation rates.

Correlation among LFA 27 estimates – The plots of annual exploitation rates for Types 1-3 (Fig. 8.3-8.5) indicate some similarity in the annual trends within subunits (the 2 sexes), but that there was considerable variation among the trends in annual estimates over the years. Since exploitation rates may well differ for males and females because of differences in distribution and targeting, we have no expectation of identical trends over time. Simple correlations for Type 1-3 estimates indicate that of 66 correlations, almost half (30) had a negative sign. All of the positive correlations > 0.5 (n=12) were of pairs of estimates within the same subunit.

8.3.2. LFAs 29 and 31A

Exploitation Estimates

Annual exploitation rates for LFA 29 and LFA 31A (Types 7-10 in text-table 8.3) are shown in Fig. 8.9. Confidence intervals are wide but tend to be narrower for the last 2-5 years depending on Type. Compared to available estimates prior to 2006, point estimates for the MLS to 90 mm CL size group were lower from 2006-2009 (Fig 8.10a,b,e,f). Correlations among the different annual series tended to be low (Table 8.10) and there were proportionately fewer correlations > 0.50 compared to LFA 27. These occurred within LFAs (males 91-100 in LFA 31 and females MLS-90) and across LFAs (Females MLS-90 in LFA 31A and males MLS-90 in LFA 29; Females MLS-90 in LFA 31A and males 91-100 in LFA 29).

8.3.3. LFA 33

Exploitation Estimates

Annual exploitation rates for LFA 33 east and west (Types 11-12 in text-table 8.2) are shown in Fig. 8.10. Confidence intervals were narrowest for males in the last 6 years in both the east (Fig. 8.11a) and the west (Fig. 8.11e and g). Confidence intervals were widest for the large sized females in both the east and west (Fig. 8.11d and h). Correlations among the different annual series again tended to be low (Table 8.11) but there were proportionately more correlations > 0.50 compared to LFAs 29 & 31A. These occurred within subunits (east: males 82.5-90 & 91-100, females 82.5-90 & 91-10; west: males 82.5-90 and females 91-100, females 82.5-90 & 91-100) and across subunits (males 82.5-90 in the west and males 91-100 in the east; females 91-100 in the east and females of the same size in the west).

Effect of Sample Size on SE of Exploitation Rate Estimates

Looking collectively at the estimates for Types 1-5 in LFA 27 there was usually a higher number of observations in the reference size class compared to the exploited size class (Fig. 8.11). The

average number of observations in the reference size class for Types 1-5 was 537 (range 116-1523) compared to an average of 286 (range 25-713) observations in the exploited size class. This difference was also the case for the estimates for LFA 29 (mean for observations in the reference size class was 314 (range 5-1324) and 176 for the exploited class (range 5-785). In LFA 33 the mean for observations in the reference class was 863 (range 41-2060) compared to 305 (range 2-785).

At sample sizes of less than about 200 the SE of the exploitation rate estimates tended to be substantially higher (Fig. 8.12). Consistently low SE's were obtained when the number of observations in both the exploited size class and the reference size class were > 200 (Fig. 8.12).

For LFAs 29 and 31a, and LFA 33, similar results were obtained with respect to the effect of the number of lobsters in the reference class on the SE of the CCIR estimate (Fig. 8.13).

Levels of Exploitation Rate Estimates in Different Assessment Units

As indicated above the CCIR estimates cannot be considered absolute as they do not consider some portions of the stock (ovigerous females, closed size windows). Nevertheless a comparison of CCIR estimates across assessment units (Text Table 8.4, Fig. 8.14) indicates spatial differences have a pattern similar to estimates using other methods such as length composition analysis. Using this method for the period 1997-2003, Tremblay and Reeves (2004) found that the rank order of exploitation rate estimates for Cape Breton LFAs (low to high) was LFA 29, LFA 27-South and LFA 27-North. This is the same rank order found using CCIR.

For the MLS-90 mm CL size class CCIR estimates of exploitation, the following estimates are obtained by averaging the estimates for males and females:

Text Table 8.4 *– Mean CCIR estimates for assessment units considered.*

Assessment unit	Subunit	Exploit size	Type	Years considered	Mean for both sexes
LFA 27	LFA 27-N	81-90	s 71_mls	2002-09	0.81
	LFA 27-S				0.74
LFAs 29-32	LFA 29	84-90		2002-09	0.54
	LFA 31A	MLS-90		2002-09	0.70
LFA 33	East	82.5-90		2002-09	0.73
	West	82.5-90			0.69

To generate a single estimate of exploitation rate per year for each assessment unit we propose the following:

(i) average the exploitation rates for the size/sex groups within subunits
(ii) average the values in (i), weighting by the landings in each subunit

A suggested format is shown in Table 8.12.

8.4. SUMMARY

The Continuous Change in Ratio (CCIR) method for estimating exploitation rates was applied to a number of assessment subunits. This method is based on the ratio of the number of lobsters in the harvested (legal, "exploited") size classes to the number of lobsters in the unharvested (sublegal, "reference") size class. How this ratio changes over the fishing season is informative of the

exploitation rate. CCIR allows the calculation of several "types" of exploitation depending on the selection of exploited size class (e.g. 81-90 or 91-100) and reference size class.

A key assumption of this method is that the ratio of catchability of the exploited and reference classes is constant throughout the season. This would be violated if for example the catch rate of lobsters in the reference class (sublegal sizes) increased over the season due to removals of larger lobsters. If this was the case we would expect a negative relationship between the catch rate of legal and sublegal sizes. This was examined for LFA 27 and it was found that the daily CPUE of sublegals had a slight positive correlation with the daily CPUE of legal sizes. As such, any antagonistic interaction between the two size groups is not detectable with the available data.

The CCIR estimates of exploitation were all significant for cases involving exploited sizes up to 90 mm CL (and where the sample size was large enough). In LFA 27 numbers in the exploited size class 91-100 were too low to provide reliable estimates. In LFA 29 & 31a and LFA 33 most estimates were significant with narrower confidence intervals for more recent years and for the MLS to 90 mm CL size class

The rank order of mean exploitation rates by assessment units estimated by CCIR is in agreement with the rank order of estimates generated using other methods, providing confidence in the CCIR estimates. The point estimates for CCIR estimates fluctuated, usually without trend, in all subunits examined. Confidence intervals indicate that with few exceptions, estimates of exploitation rate have not changed over the time period of available data (1999-2009). The "extended" exploitation rate estimates for LFA 27 indicate that exploitation rate is significantly lower than if lobsters 76-81 mm CL were still retained.

The CCIR estimates should be viewed as an index of exploitation that allows tracking of exploitation rate over years. The strict estimates do not account for unexploited portions of the population (ovigerous females, window females, lobsters in newly protected size groups).

With regard to using CCIR for the assessment, the minimum number of lobsters in the reference and exploited size classes should be 200 or greater. Exploitation rate estimates for sizes > 90 mm CL in several subunits have confidence intervals that are too broad to be useful as an indicator of exploitation rate. The CCIR estimates for Type 2 (81-90 vs 76-81) should be used as in indicator. If a removal reference point is to be developed, estimates should be provided for assessment units based on means of subunit estimates, weighted by landings where this is possible.

8.5. TABLES

***Table 8.1** – Description and results of exploitation rate Type 1 for northern subunit in LFA 27, males.*

LFA	ReportingAreaDesc	Description	Sex	Year	MLS	Ref.Lower.Incl.mm	Ref.Upper.Excl.mm	Exp.Lower.Incl.mm	Exp.Upper.Excl.mm
27	1,4	Type 1	1	1999	73.0	71	73.0	73.0	81
27	1,4	Type 1	1	2000	73.0	71	73.0	73.0	81
27	1,4	Type 1	1	2001	74.5	71	74.5	74.5	81
27	1,4	Type 1	1	2002	76.0	71	76.0	76.0	81
27	1,4	Type 1	1	2003	76.0	71	76.0	76.0	81
27	1,4	Type 1	1	2004	76.0	71	76.0	76.0	81
27	1,4	Type 1	1	2005	76.0	71	76.0	76.0	81
27	1,4	Type 1	1	2006	76.0	71	76.0	76.0	81
27	1,4	Type 1	1	2007	77.5	71	77.5	77.5	81
27	1,4	Type 1	1	2008	79.0	71	79.0	79.0	81

Year	DateStart	DateEnd	n.Cal.Days	n.Days	n.Lobst.Ref	n.Lobst.Exp	Expl.rate	SE	alpha	C.I.L	C.I.R
1999	1999-05-17	1999-07-15	59	51	223	460	58.0	10.2	0.05	40.4	80.7
2000	2000-05-16	2000-07-15	60	51	116	333	85.3	5.1	0.05	77.4	97.0
2001	2001-05-14	2001-07-12	59	51	256	390	71.6	7.4	0.05	59.9	88.5
2002	2002-05-13	2002-07-11	59	53	354	258	93.2	3.1	0.05	88.9	101.0
2003	2003-05-16	2003-07-14	59	51	623	546	71.0	5.8	0.05	61.4	83.9
2004	2004-05-17	2004-07-14	58	51	731	455	82.5	4.2	0.05	75.8	92.6
2005	2005-05-17	2005-07-16	60	52	695	426	85.2	3.6	0.05	79.5	93.6
2006	2006-05-15	2006-07-15	61	54	761	564	72.9	5.3	0.05	64.3	85.2
2007	2007-05-17	2007-07-11	55	47	893	175	71.0	10.6	0.05	57.2	98.7
2008	2008-05-17	2008-07-16	60	54	1410	253	83.2	5.0	0.05	75.7	95.9

***Table 8.2** – Description and results of exploitation rate Type 1 for northern subunit in LFA 27, females.*

LFA	ReportingAreaDesc	Description	Sex	Year	MLS	Ref.Lower.Incl.mm	Ref.Upper.Excl.mm	Exp.Lower.Incl.mm	Exp.Upper.Excl.mm
27	1,4	Type 1	2	1999	73.0	71	73.0	73.0	81
27	1,4	Type 1	2	2000	73.0	71	73.0	73.0	81
27	1,4	Type 1	2	2001	74.5	71	74.5	74.5	81
27	1,4	Type 1	2	2002	76.0	71	76.0	76.0	81
27	1,4	Type 1	2	2003	76.0	71	76.0	76.0	81
27	1,4	Type 1	2	2004	76.0	71	76.0	76.0	81
27	1,4	Type 1	2	2005	76.0	71	76.0	76.0	81
27	1,4	Type 1	2	2006	76.0	71	76.0	76.0	81
27	1,4	Type 1	2	2007	77.5	71	77.5	77.5	81
27	1,4	Type 1	2	2008	79.0	71	79.0	79.0	81

Year	DateStart	DateEnd	n.Cal.Days	n.Days	n.Lobst.Ref	n.Lobst.Exp	Expl.rate	SE	alpha	C.I.L	C.I.R
1999	1999-05-17	1999-07-15	59	52	207	391	64.8	9.2	0.05	50.1	84.7
2000	2000-05-16	2000-07-15	60	51	126	357	76.1	7.8	0.05	63.8	94.6
2001	2001-05-14	2001-07-12	59	53	283	393	72.5	7.2	0.05	61.0	89.8
2002	2002-05-13	2002-07-11	59	53	344	198	84.5	6.4	0.05	75.7	101.1
2003	2003-05-16	2003-07-14	59	51	638	389	76.9	5.5	0.05	68.4	89.8
2004	2004-05-17	2004-07-14	58	51	726	410	85.6	3.7	0.05	79.9	94.6
2005	2005-05-15	2005-07-17	63	54	796	344	79.8	4.9	0.05	72.4	91.5
2006	2006-05-15	2006-07-15	61	54	832	490	65.4	7.0	0.05	53.9	80.9
2007	2007-05-16	2007-07-12	57	50	809	109	75.0	11.7	0.05	60.3	105.1
2008	2008-05-17	2008-07-16	60	54	1523	221	90.3	4.0	0.05	84.8	100.5

***Table 8.3** – Description and results of exploitation rate Type 1 for southern subunit in LFA 27, males.*

LFA	ReportingAreaDesc	Description	Sex	Year	MLS	Ref.Lower.Incl.mm	Ref.Upper.Excl.mm	Exp.Lower.Incl.mm	Exp.Upper.Excl.mm
27	6,7	Type 1	1	1999	73.0	71	73.0	73.0	81
27	6,7	Type 1	1	2000	73.0	71	73.0	73.0	81
27	6,7	Type 1	1	2001	74.5	71	74.5	74.5	81
27	6,7	Type 1	1	2002	76.0	71	76.0	76.0	81
27	6,7	Type 1	1	2003	76.0	71	76.0	76.0	81
27	6,7	Type 1	1	2004	76.0	71	76.0	76.0	81
27	6,7	Type 1	1	2005	76.0	71	76.0	76.0	81
27	6,7	Type 1	1	2006	76.0	71	76.0	76.0	81
27	6,7	Type 1	1	2007	77.5	71	77.5	77.5	81
27	6,7	Type 1	1	2008	79.0	71	79.0	79.0	81

Year	DateStart	DateEnd	n.Cal.Days	n.Days	n.Lobst.Ref	n.Lobst.Exp	Expl.rate	SE	alpha	C.I.L	C.I.R
1999	1999-05-16	1999-07-15	60	56	165	383	69.8	8.8	0.05	55.2	89.8
2000	2000-05-16	2000-07-15	60	55	181	473	78.5	5.3	0.05	68.9	89.5
2001	2001-05-13	2001-07-14	62	60	227	406	70.4	8.3	0.05	57.0	89.9
2002	2002-05-13	2002-07-11	59	55	281	257	60.3	12.3	0.05	41.4	88.5
2003	2003-05-16	2003-07-15	60	56	357	264	79.7	6.0	0.05	71.1	94.9
2004	2004-05-17	2004-07-15	59	53	343	259	66.5	10.5	0.05	51.9	92.5
2005	2005-05-17	2005-07-16	60	56	396	319	64.1	10.2	0.05	48.7	88.0
2006	2006-05-14	2006-07-14	61	60	544	410	88.7	3.3	0.05	83.6	96.4
2007	2007-05-14	2007-09-14	123	59	785	359	61.8	9.4	0.05	47.3	83.7
2008	2008-05-18	2008-07-27	70	60	1059	354	83.7	4.2	0.05	77.5	93.6

***Table 8.4** – Description and results of exploitation rate Type 1 for southern subunit in LFA 27, females.*

LFA	ReportingAreaDesc	Description	Sex	Year	MLS	Ref.Lower.Incl.mm	Ref.Upper.Excl.mm	Exp.Lower.Incl.mm	Exp.Upper.Excl.mm
27	6,7	Type 1	2	1999	73.0	71	73.0	73.0	81
27	6,7	Type 1	2	2000	73.0	71	73.0	73.0	81
27	6,7	Type 1	2	2001	74.5	71	74.5	74.5	81
27	6,7	Type 1	2	2002	76.0	71	76.0	76.0	81
27	6,7	Type 1	2	2003	76.0	71	76.0	76.0	81
27	6,7	Type 1	2	2004	76.0	71	76.0	76.0	81
27	6,7	Type 1	2	2005	76.0	71	76.0	76.0	81
27	6,7	Type 1	2	2006	76.0	71	76.0	76.0	81
27	6,7	Type 1	2	2007	77.5	71	77.5	77.5	81
27	6,7	Type 1	2	2008	79.0	71	79.0	79.0	81

Year	DateStart	DateEnd	n.Cal.Days	n.Days	n.Lobst.Ref	n.Lobst.Exp	Expl.rate	SE	alpha	C.I.L	C.I.R
1999	1999-05-16	1999-07-15	60	56	203	375	78.6	5.9	0.05	68.9	91.8
2000	2000-05-16	2000-07-15	60	56	151	452	75.8	6.6	0.05	64.7	89.9
2001	2001-05-13	2001-07-12	60	55	218	392	74.9	6.9	0.05	63.7	90.3
2002	2002-05-13	2002-07-11	59	55	254	246	50.1	15.7	0.05	27.1	89.7
2003	2003-05-16	2003-07-15	60	52	406	246	73.0	9.1	0.05	60.2	96.2
2004	2004-05-16	2004-07-15	60	55	346	242	69.1	10.2	0.05	55.1	95.2
2005	2005-05-17	2005-07-16	60	59	353	236	82.1	6.0	0.05	73.6	96.5
2006	2006-05-14	2006-07-17	64	61	570	371	69.3	7.5	0.05	57.3	87.1
2007	2007-05-14	2007-07-12	59	60	762	288	66.7	8.0	0.05	54.6	86.5
2008	2008-05-18	2008-07-21	64	61	917	318	70.0	7.2	0.05	58.2	86.7

***Table 8.5** – Description and results of exploitation rate Type 2 for northern subunit in LFA 27, males.*

LFA 27 - Estimate 81_90vs71_MLS - Districts 1,4 - Sex 1

LFA	ReportingAreaDesc	Description	Sex	Year	MLS	Ref.Lower.Incl.mm	Ref.Upper.Excl.mm	Exp.Lower.Incl.mm	Exp.Upper.Excl.mm
27	1,4	81_90vs71_MLS	1	1999	73.0	71	73.0	81	90
27	1,4	81_90vs71_MLS	1	2000	73.0	71	73.0	81	90
27	1,4	81_90vs71_MLS	1	2001	74.5	71	74.5	81	90
27	1,4	81_90vs71_MLS	1	2002	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	1	2003	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	1	2004	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	1	2005	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	1	2006	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	1	2007	77.5	71	77.5	81	90
27	1,4	81_90vs71_MLS	1	2008	79.0	71	79.0	81	90
27	1,4	81_90vs71_MLS	1	2009	81.0	71	81.0	81	90

Year	DateStart	DateEnd	n.Cal.Days	n.Days	n.Lobst.Ref	n.Lobst.Exp	Expl.rate	SE	alpha	C.I.L	C.I.R
1999	1999-05-17	1999-07-15	59	51	223	204	83.5	5.8	0.05	75.3	98.1
2000	2000-05-16	2000-07-14	59	47	116	181	86.2	5.8	0.05	77.6	100.1
2001	2001-05-14	2001-07-12	59	51	256	258	72.6	8.6	0.05	59.7	93.0
2002	2002-05-13	2002-07-11	59	53	354	340	89.6	3.5	0.05	84.4	98.3
2003	2003-05-16	2003-07-14	59	51	623	388	77.6	5.6	0.05	69.3	91.6
2004	2004-05-17	2004-07-14	58	51	731	477	86.0	3.3	0.05	80.9	93.9
2005	2005-05-15	2005-07-17	63	55	695	446	92.3	2.3	0.05	88.9	97.8
2006	2006-05-15	2006-07-15	61	54	761	591	86.4	2.9	0.05	81.7	93.1
2007	2007-05-17	2007-07-11	55	48	893	379	76.9	5.4	0.05	68.3	89.9
2008	2008-05-17	2008-07-16	60	54	1410	578	89.0	2.3	0.05	85.2	94.0
2009	2009-05-02	2009-07-15	74	54	1198	446	88.6	2.8	0.05	84.1	95.3

***Table 8.6** – Description and results of exploitation rate Type 2 for northern subunit in LFA 27, females.*

LFA	ReportingAreaDesc	Description	Sex	Year	MLS	Ref.Lower.Incl.mm	Ref.Upper.Excl.mm	Exp.Lower.Incl.mm	Exp.Upper.Excl.mm
27	1,4	81_90vs71_MLS	2	1999	73.0	71	73.0	81	90
27	1,4	81_90vs71_MLS	2	2000	73.0	71	73.0	81	90
27	1,4	81_90vs71_MLS	2	2001	74.5	71	74.5	81	90
27	1,4	81_90vs71_MLS	2	2002	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	2	2003	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	2	2004	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	2	2005	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	2	2006	76.0	71	76.0	81	90
27	1,4	81_90vs71_MLS	2	2007	77.5	71	77.5	81	90
27	1,4	81_90vs71_MLS	2	2008	79.0	71	79.0	81	90
27	1,4	81_90vs71_MLS	2	2009	81.0	71	81.0	81	90

Year	DateStart	DateEnd	n.Cal.Days	n.Days	n.Lobst.Ref	n.Lobst.Exp	Expl.rate	SE	alpha	C.I.L	C.I.R
1999	1999-05-17	1999-07-14	58	51	207	121	59.9	18.0	0.05	37.6	107.6
2000	2000-05-16	2000-07-14	59	47	126	111	91.4	5.9	0.05	84.4	106.2
2001	2001-05-14	2001-07-12	59	52	283	211	73.6	9.1	0.05	60.7	96.1
2002	2002-05-13	2002-07-11	59	53	344	179	92.4	4.0	0.05	86.7	101.9
2003	2003-05-16	2003-07-14	59	51	638	241	72.3	7.6	0.05	60.8	91.3
2004	2004-05-17	2004-07-14	58	51	726	293	74.8	6.6	0.05	64.9	91.0
2005	2005-05-15	2005-07-17	63	53	796	257	74.7	6.5	0.05	64.9	90.8
2006	2006-05-15	2006-07-15	61	54	832	373	81.1	4.9	0.05	73.4	92.7
2007	2007-05-16	2007-07-12	57	50	809	189	82.8	6.3	0.05	73.2	98.2
2008	2008-05-17	2008-07-21	65	55	1523	433	86.2	3.4	0.05	81.1	94.4
2009	2009-05-02	2009-07-15	74	53	1049	286	71.9	7.1	0.05	60.9	88.7

Table 8.7 – Description and results of exploitation rate Type 2 for southern subunit in LFA 27, males.

LFA	ReportingAreaDesc	Description	Sex	Year	MLS	Ref.Lower.Incl.mm	Ref.Upper.Excl.mm	Exp.Lower.Incl.mm	Exp.Upper.Excl.mm
27	6,7	81_90vs71_MLS	1	1999	73.0	71	73.0	81	90
27	6,7	81_90vs71_MLS	1	2000	73.0	71	73.0	81	90
27	6,7	81_90vs71_MLS	1	2001	74.5	71	74.5	81	90
27	6,7	81_90vs71_MLS	1	2002	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	1	2003	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	1	2004	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	1	2005	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	1	2006	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	1	2007	77.5	71	77.5	81	90
27	6,7	81_90vs71_MLS	1	2008	79.0	71	79.0	81	90
27	6,7	81_90vs71_MLS	1	2009	81.0	71	81.0	81	90

Year	DateStart	DateEnd	n.Cal.Days	n.Days	n.Lobst.Ref	n.Lobst.Exp	Expl.rate	SE	alpha	C.I.L	C.I.R
1999	1999-05-16	1999-07-15	60	53	165	193	40.4	22.0	0.05	10.1	96.6
2000	2000-05-16	2000-07-15	60	54	181	244	81.0	6.2	0.05	71.6	95.4
2001	2001-05-13	2001-07-12	60	56	227	233	79.0	7.0	0.05	68.4	95.3
2002	2002-05-13	2002-07-11	59	55	281	225	55.8	14.5	0.05	35.9	92.3
2003	2003-05-16	2003-07-15	60	57	357	297	77.0	6.7	0.05	67.1	93.1
2004	2004-05-16	2004-07-15	60	55	343	347	59.8	11.5	0.05	42.9	88.0
2005	2005-05-17	2005-07-16	60	57	396	422	74.2	6.7	0.05	63.8	88.9
2006	2006-05-14	2006-07-14	61	61	544	574	88.4	2.9	0.05	83.6	95.1
2007	2007-05-14	2007-09-14	123	61	785	569	56.0	8.6	0.05	42.0	75.3
2008	2008-05-18	2008-07-27	70	61	1059	713	81.2	3.3	0.05	75.8	88.7
2009	2009-05-16	2009-07-15	60	55	655	453	84.6	3.8	0.05	78.8	93.7

***Table 8.8** – Description and results of exploitation rate Type 2 for southern subunit in LFA 27, females.*

LFA	ReportingAreaDesc	Description	Sex	Year	MLS	Ref.Lower.Incl.mm	Ref.Upper.Excl.mm	Exp.Lower.Incl.mm	Exp.Upper.Excl.mm
27	6,7	81_90vs71_MLS	2	1999	73.0	71	73.0	81	90
27	6,7	81_90vs71_MLS	2	2000	73.0	71	73.0	81	90
27	6,7	81_90vs71_MLS	2	2001	74.5	71	74.5	81	90
27	6,7	81_90vs71_MLS	2	2002	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	2	2003	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	2	2004	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	2	2005	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	2	2006	76.0	71	76.0	81	90
27	6,7	81_90vs71_MLS	2	2007	77.5	71	77.5	81	90
27	6,7	81_90vs71_MLS	2	2008	79.0	71	79.0	81	90
27	6,7	81_90vs71_MLS	2	2009	81.0	71	81.0	81	90

Year	DateStart	DateEnd	n.Cal.Days	n.Days	n.Lobst.Ref	n.Lobst.Exp	Expl.rate	SE	alpha	C.I.L	C.I.R
1999	1999-05-17	1999-07-15	59	55	203	160	87.9	5.2	0.05	81.0	101.2
2000	2000-05-16	2000-07-15	60	52	151	183	85.1	6.5	0.05	76.4	101.3
2001	2001-05-14	2001-07-12	59	51	218	200	79.1	7.6	0.05	68.4	97.2
2002	2002-05-13	2002-07-11	59	53	254	167	76.7	9.5	0.05	64.3	101.2
2003	2003-05-16	2003-07-15	60	53	406	240	81.5	6.6	0.05	72.1	98.0
2004	2004-05-16	2004-07-15	60	56	346	234	78.2	7.7	0.05	67.4	98.1
2005	2005-05-17	2005-07-16	60	59	353	211	64.4	11.6	0.05	47.1	93.2
2006	2006-05-14	2006-07-17	64	61	570	358	87.4	3.6	0.05	81.9	96.4
2007	2007-05-14	2007-07-12	59	60	762	331	74.9	6.1	0.05	65.4	89.2
2008	2008-05-18	2008-07-27	70	62	917	454	72.6	5.6	0.05	63.5	85.5
2009	2009-05-16	2009-07-15	60	54	596	282	67.7	8.6	0.05	55.0	88.7

***Table 8.9** – Correlations among Type 1-3 exploitation types, LFA 27. Method was Spearman, done pairwise. First 2 characters are type (T1, T2 or T3), 3rd character is sex (M or F) and last 2 characters are LFA 27 subunit (1,4 or 6,7). Positive correlations >= 0.5 are highlighted.*

	T1M14	T1F14	T1M67	T1F67	T2M14	T2F14	T2M67	T2F67	T3M14	T3F14	T3M67	T3F67
T1M14	**1.00**	0.60	-0.21	-0.15	0.76	0.78	0.20	-0.44	0.93	0.50	-0.32	-0.71
T1F14		**1.00**	-0.16	-0.31	0.50	0.45	0.05	-0.71	0.36	0.29	-0.18	-0.57
T1M67			**1.00**	0.25	-0.07	-0.15	0.83	0.44	-0.21	-0.29	0.96	0.46
T1F67				**1.00**	0.03	-0.55	0.13	0.20	0.11	-0.71	0.64	-0.18
T2M14					**1.00**	0.35	0.18	-0.50	0.90	0.24	0.02	-0.71
T2F14						**1.00**	0.04	-0.13	0.43	0.98	-0.45	-0.05
T2M67							**1.00**	-0.07	-0.12	-0.40	1.00	0.14
T2F67								**1.00**	-0.38	0.02	0.10	0.95
T3M14									**1.00**	0.48	-0.12	-0.57
T3F14										**1.00**	-0.40	-0.14
T3M67											**1.00**	0.14
T3F67												**1.00**

Table 8.10 – Correlations among Type 7-10 exploitation types, LFA 29 and 31a. Method was Spearman, done pairwise. First 2-3 characters are type, next character is sex (M or F) and last 2 characters are LFA (29 or 31A). Positive correlations >= 0.5 are highlighted.

	T7M29	T7F29	T8M29	T8F29	T9M31	T9F31	T10M31	T10F31
T7M29	1.00	0.10	1.00	0.10	0.44	0.58	0.22	-0.79
T7F29		**1.00**	0.10	1.00	0.00	0.38	0.30	-0.24
T8M29			**1.00**	0.10	0.44	0.58	0.22	-0.79
T8F29				**1.00**	0.00	0.38	0.30	-0.24
T9M31					**1.00**	-0.19	0.24	-0.52
T9F31						**1.00**	0.66	-0.83
T10M31							**1.00**	-0.62
T10F31								**1.00**

***Table 8.11** – Correlations among Type 11-12 exploitation types, LFA 33 east and west. Method was Spearman, done pairwise. First 3 characters are type (11 or 12, see text-table 8.2), next character is sex (M or F) and last character identifies subunit of LFA 33 (E for east, W for west). Positive correlations >= 0.5 are highlighted.*

	T12ME	T12FE	T11ME	T11FE	T12MW	T12FW	T11MW	T11FW
T12ME	1.00	0.48	0.71	0.47	-0.19	0.26	0.71	-0.08
T12FE		1.00	0.15	0.83	0.15	0.55	0.45	0.45
T11ME			1.00	0.19	-0.47	0.21	0.42	-0.48
T11FE				1.00	0.07	0.30	0.27	0.28
T12MW					1.00	0.39	0.24	0.35
T12FW						1.00	0.73	0.70
T11MW							1.00	0.43
T11FW								1.00

Table 8.12 – *Suggested format for providing exploitation rate estimate for all areas.*

Year	LFA 27N	LFA27S	LFA 27 All
1999			
2000			
2001			
2002			
2003			
2004			
2005			
2006			
2007			
2008			
2009			

Year	LFA 29	LFA 30	LFA 31a	LFA 31b	LFA 32	LFAs 29-32 All
1999						
2000						
2001						
2002						
2003						
2004						
2005						
2006						
2007						
2008						
2009						

8.6. FIGURES

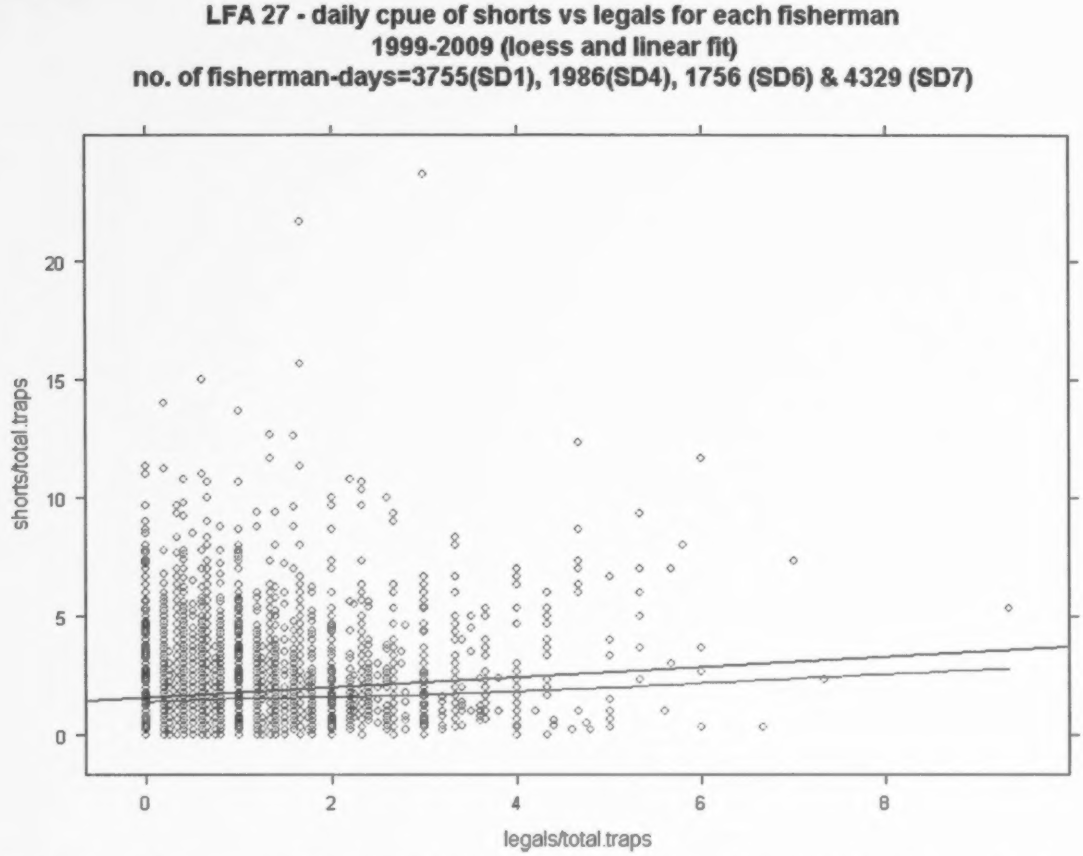


Figure 8.1 – LFA 27, 1999-2009. Plots of daily catch rates of sublegal lobsters ("shorts) versus legal size lobsters. Each point represents the data from one fisherman from 2-5 traps.

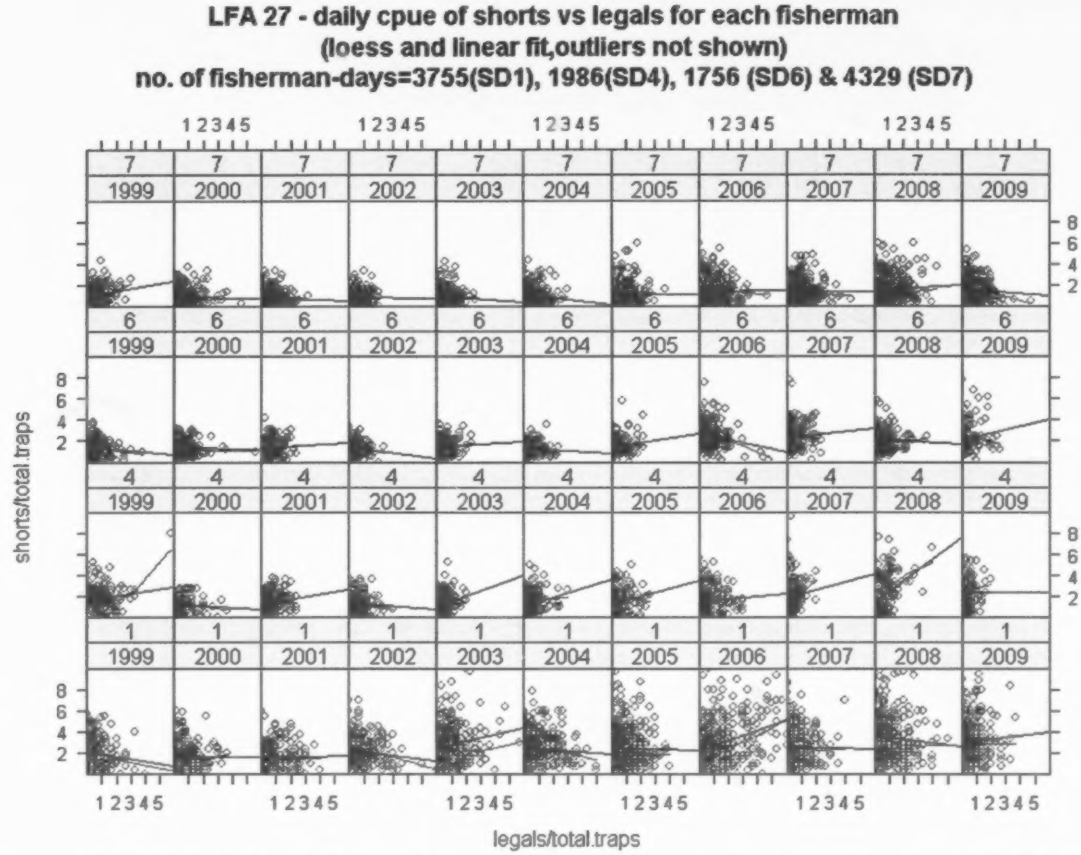


Figure 8.2 – LFA 27 daily CPUE (number per trap haul) of sublegal sizes ("shorts") versus daily CPUE of legal sizes for individual fishermen for each year and Statistical District (SD; SD = 1, 4, 6 and 7). Each point represents the data from one fisherman from 2-5 traps.

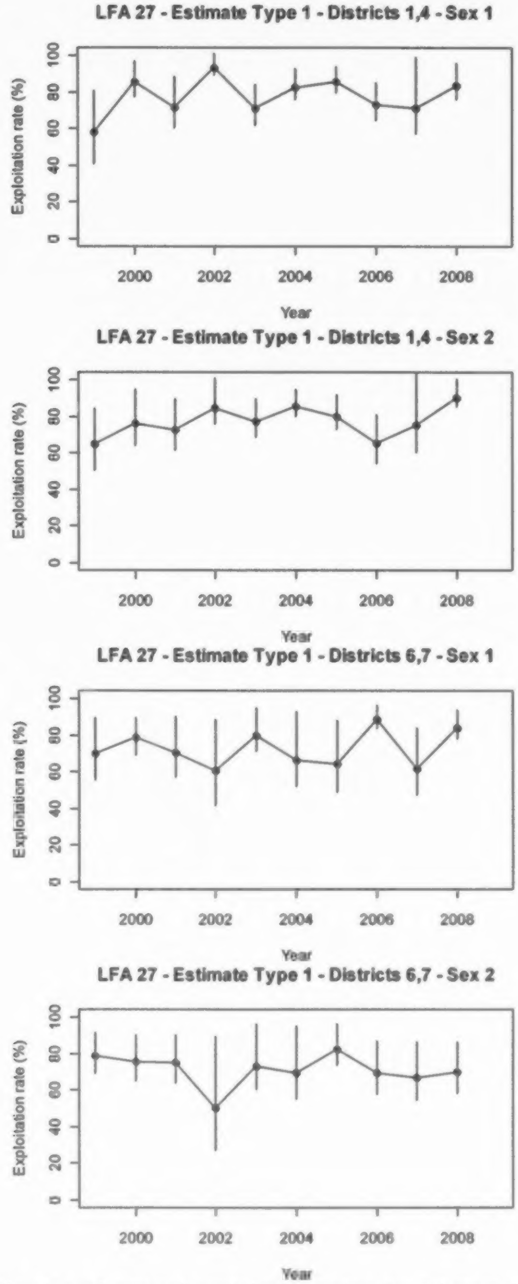


***Figure 8.3** – LFA 27 - Estimates of annual exploitation rates for lobsters in exploited size class MLS to 81 mm CL with reference class= 71 mm CL to MLS. (Type 1).*

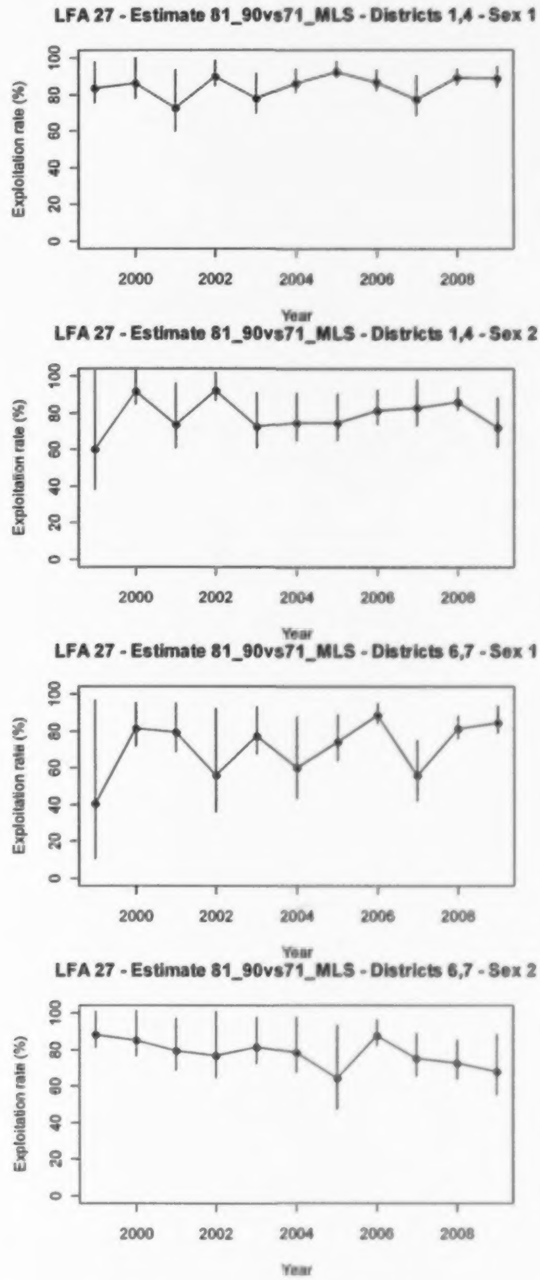


Figure 8.4 – *LFA 27 - Estimates of annual exploitation rates for lobsters in exploited size class 81-90 mm CL with reference class= 71 mm CL to MLS (Type 2).*

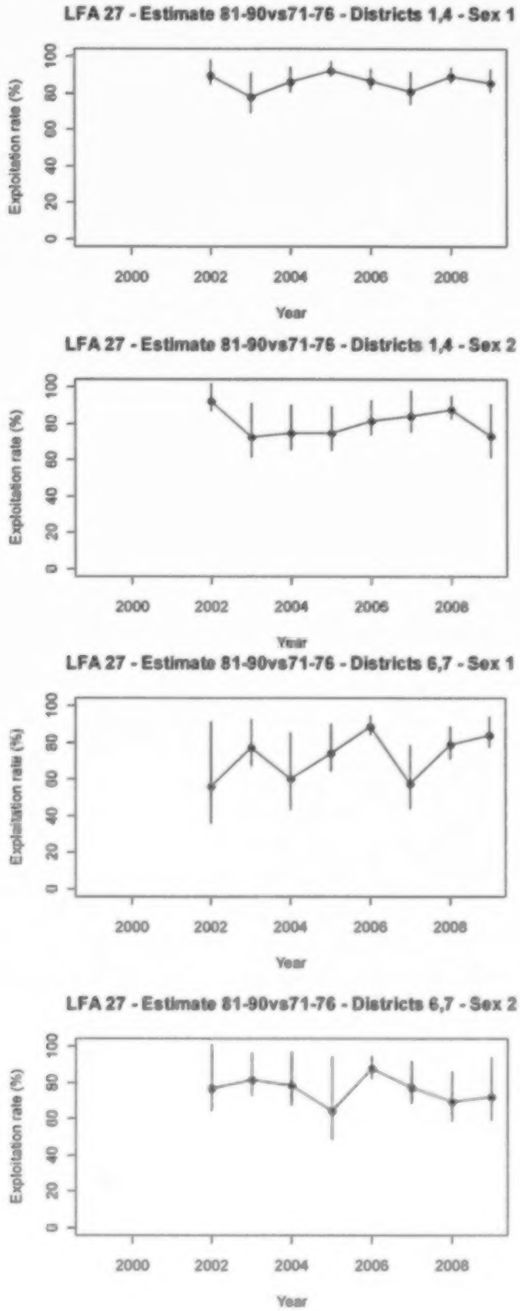


Figure 8.5 *– LFA 27 - Estimates of annual exploitation rates for lobsters in exploited size class 81-90 mm CL with reference class = 71-76 mm CL (Type 3).*

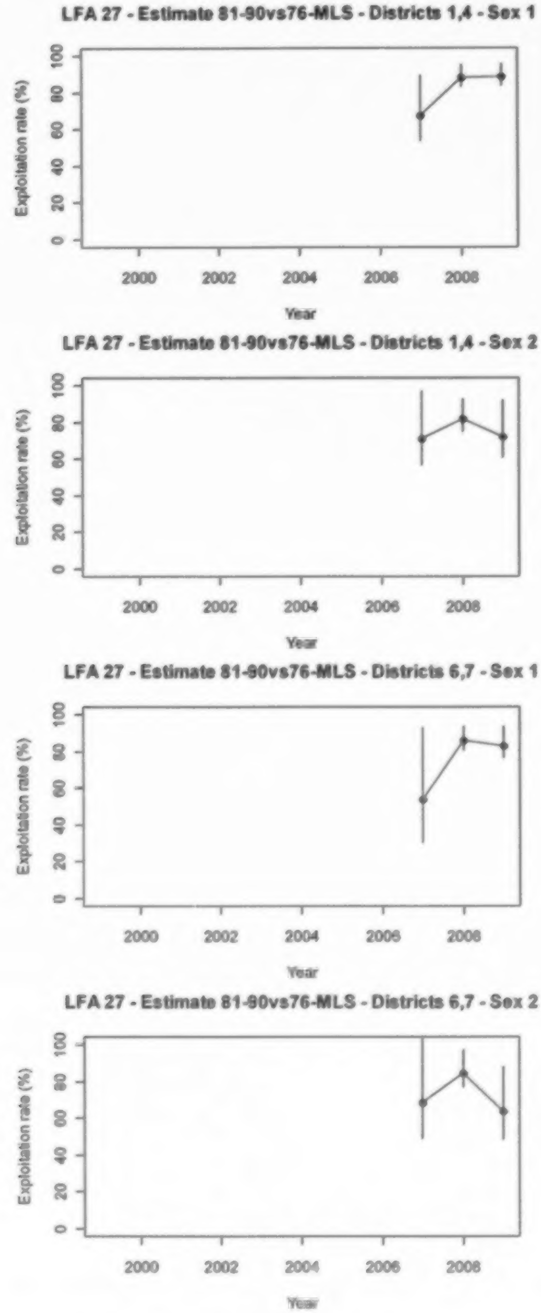


***Figure 8.6** – LFA 27 - Estimates of annual exploitation rates for lobsters in exploited size class 81-90 mm CL with reference class= 76 mm CL to MLS (Type 4).*

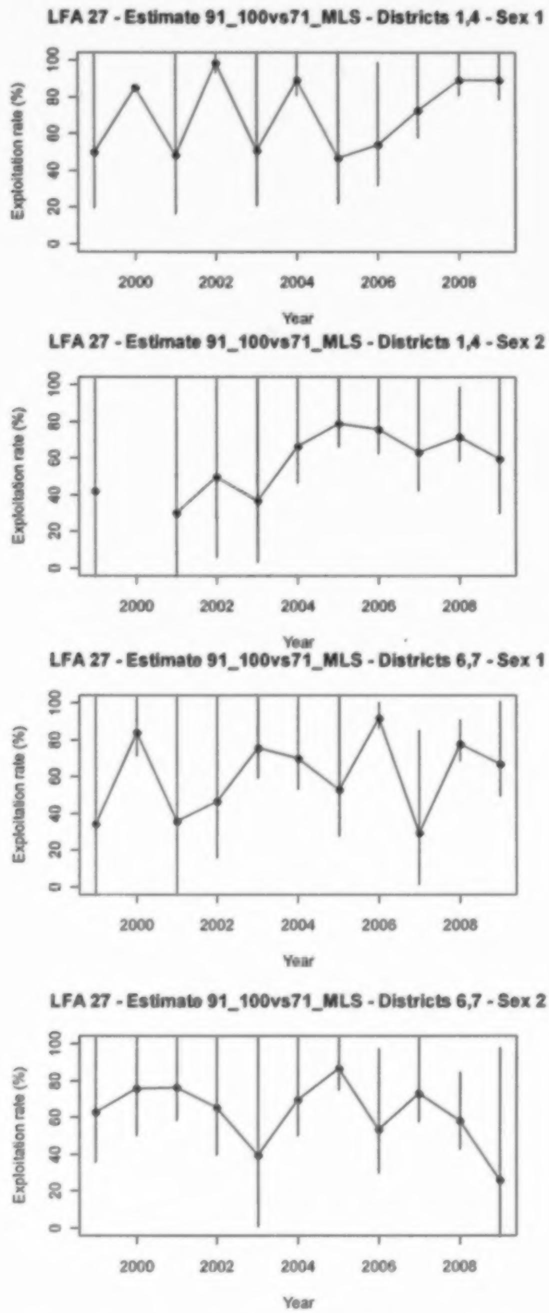


***Figure 8.7** – LFA 27 - Estimates of annual exploitation rates for lobsters in exploited size class 91-100 mm CL with reference class= 71 mm CL to MLS (Type 5).*

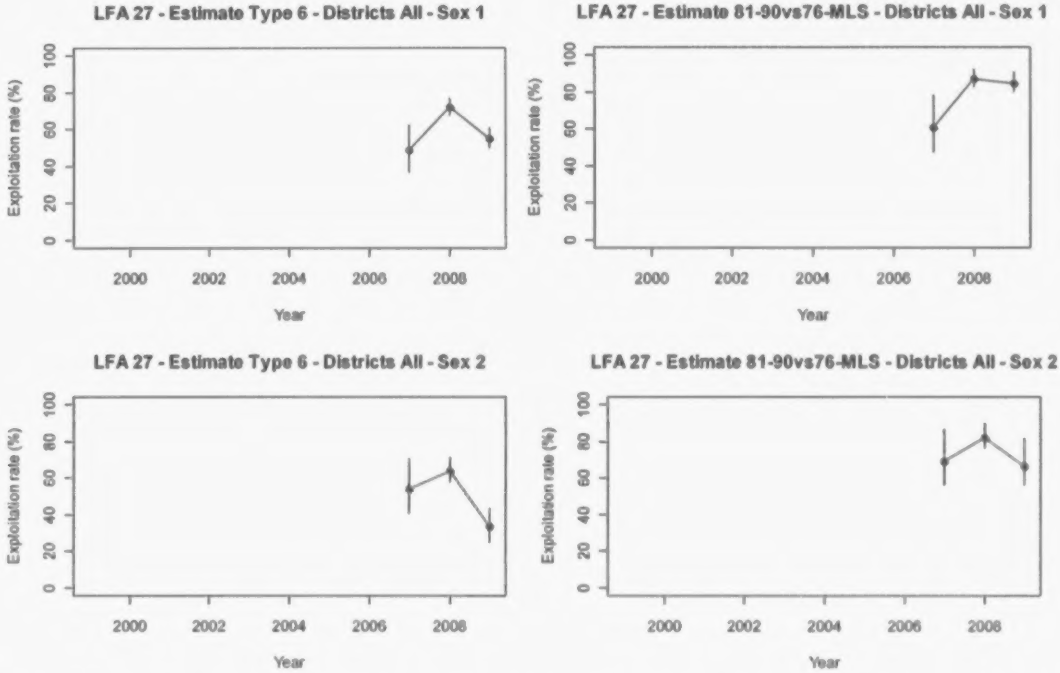


***Figure 8.8** – LFA 27 - Extended estimates of annual exploitation (Type 6, left panel) versus standard estimates of annual exploitation (Type 4, right panel) for LFA 27 subunits combined. Extended estimates include newly protected sizes (76-81 mm CL) with exploited size class.*

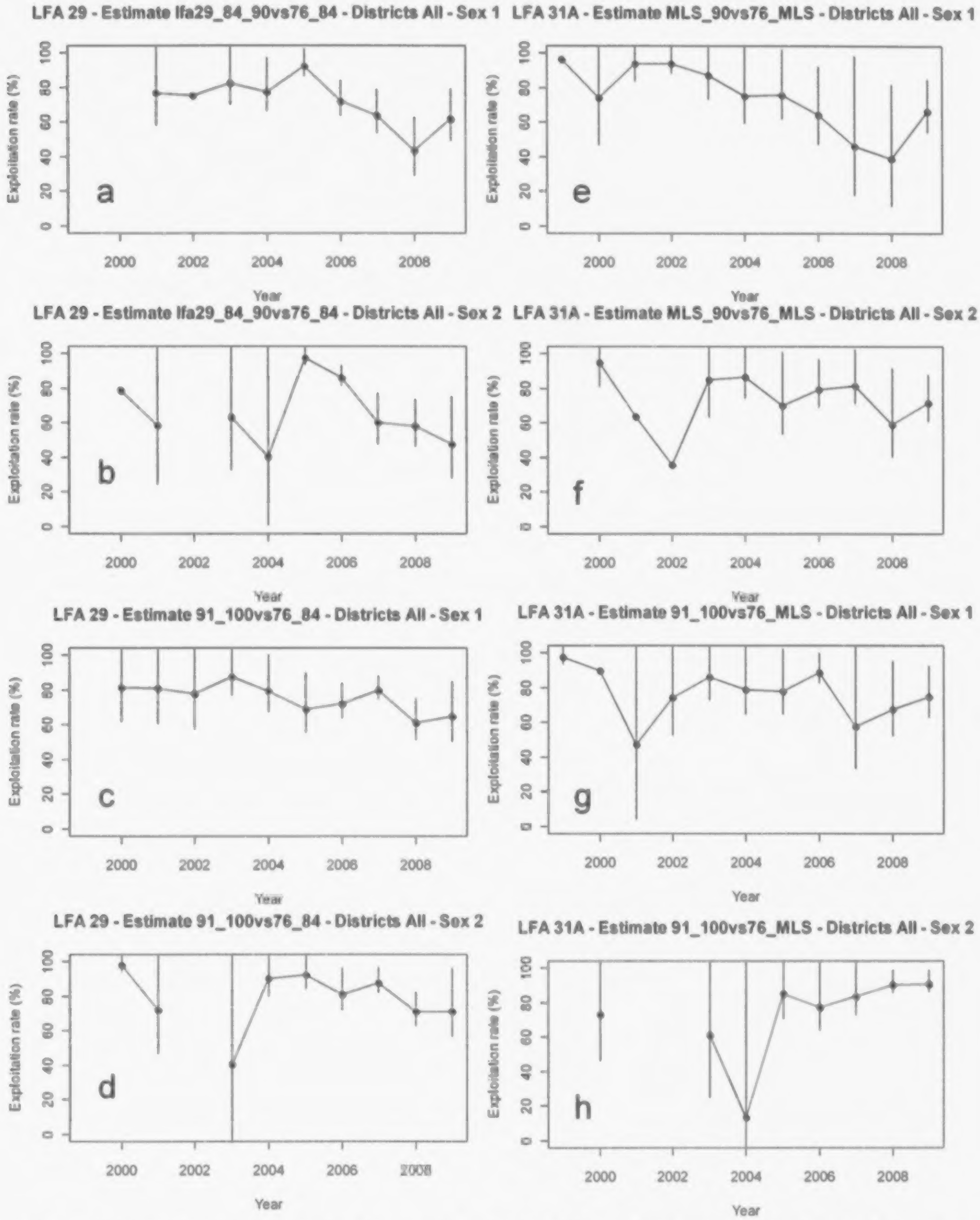


***Figure 8.9** – Exploitation rate estimates for subunits LFA 29 (left panel, a-d) and LFA 31a (right panel, e-h).*

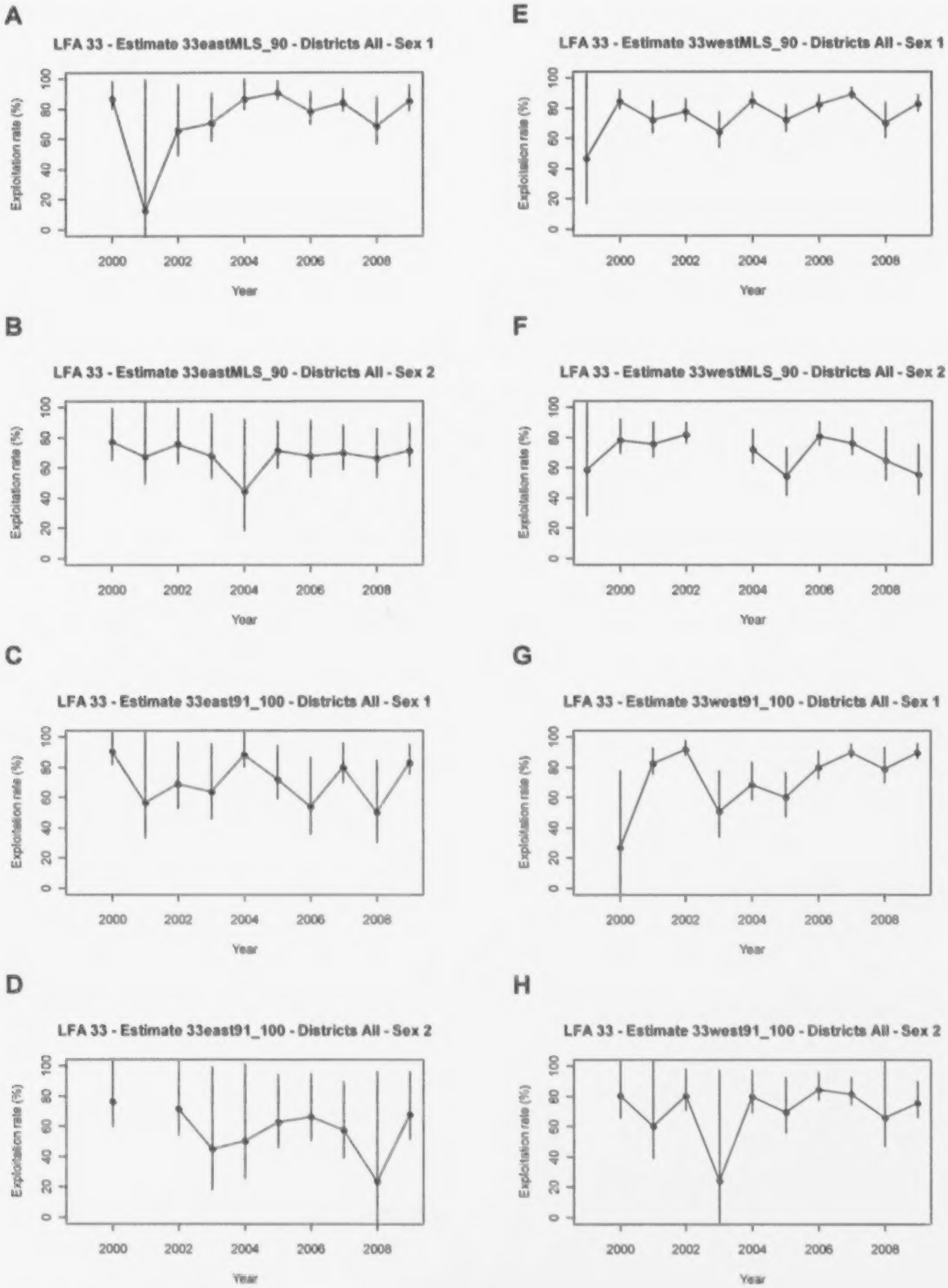


Figure 8.10 – Exploitation rate estimates for subunits LFA 33-east (left panel, a-d) and LFA 33-west (right panel, e-h).

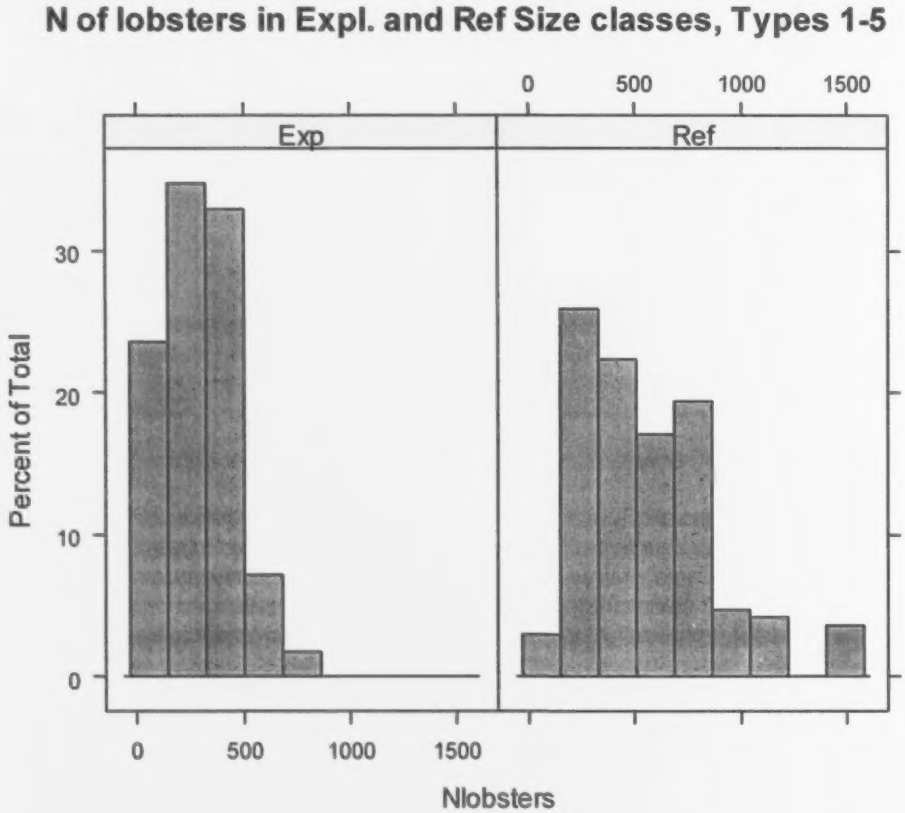


Figure 8.11 – Number of observations in exploited and reference size classes, exploitation types 1-5 (LFA 27).

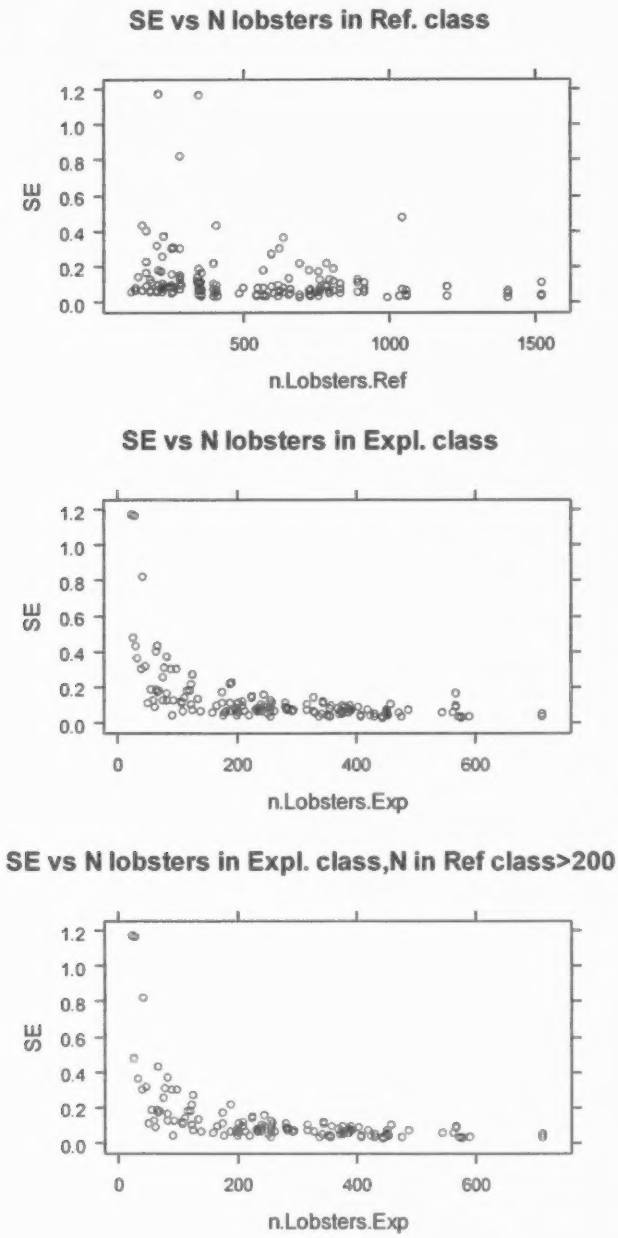


***Figure 8.12** – LFA 27 CCIR results - Standard error (SE) vs number of lobsters in reference (ref) and exploited (Expl.) and size classes. Lowest panel shows data for those estimates where the number in the ref class was > 200. Data are from Type 1-5 estimates (N estimates=170).*

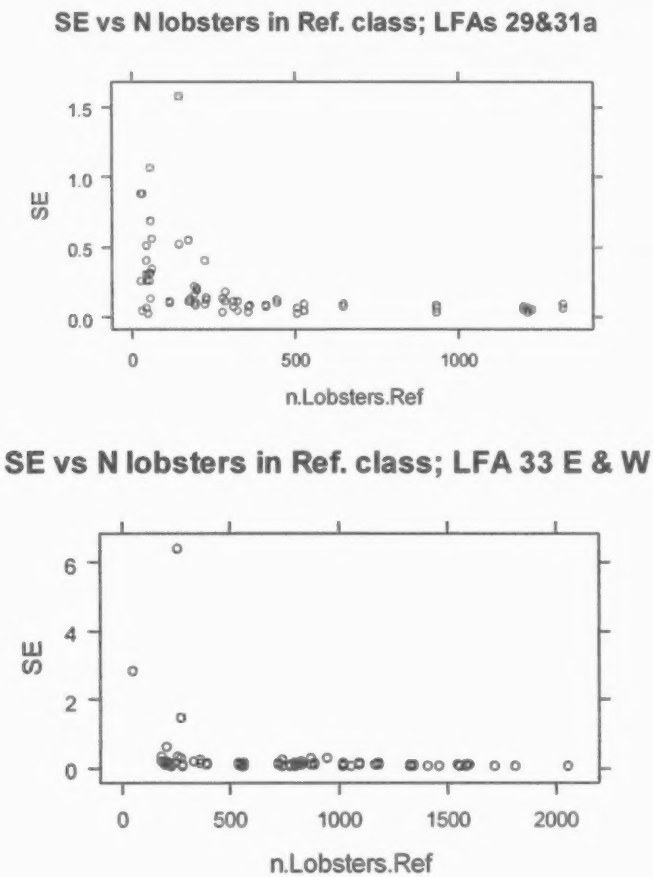


Figure 8.13 *– LFA 27 CCIR results LFAs 29 & 31A (upper panel) and LFA 33 (lower panel). Shown is standard error (SE) vs number of lobsters in reference (ref) size classes.*

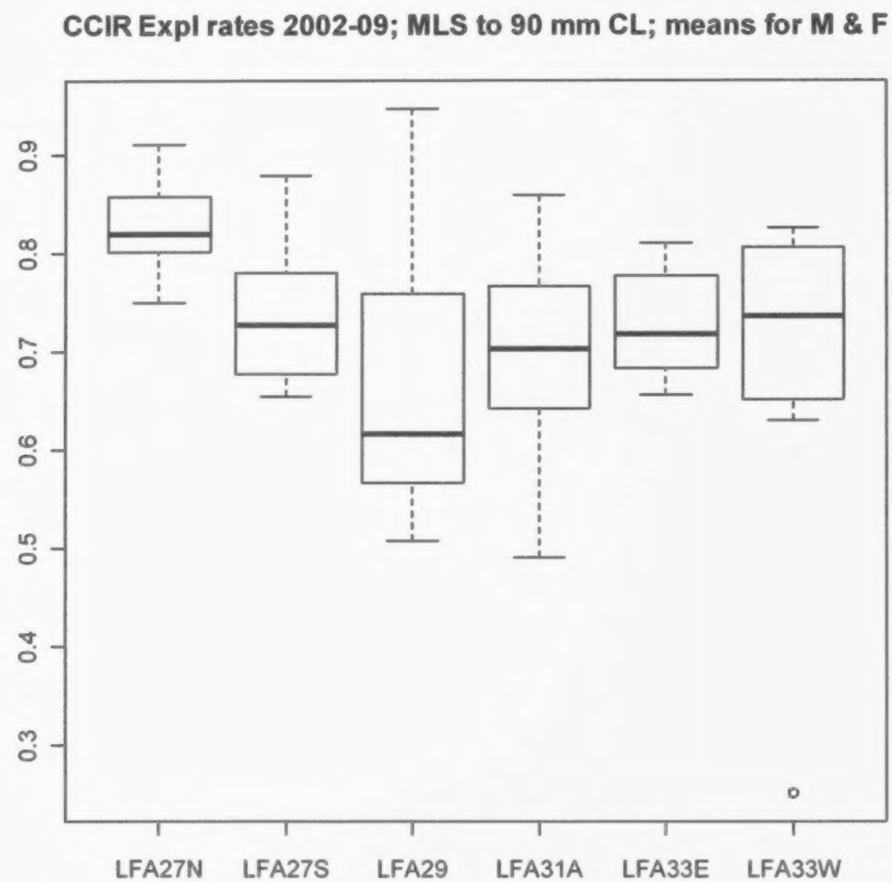


Figure 8.14 *– Box-whisker plots for CCIR exploitation rates by assessment subunit, 2002-2009. Estimates are for the size group (Minimum legal size (MLS) to 90 mm CL; male and female estimates averaged. Horizontal bars indicate the median; box limits correspond to lower and upper quartiles (Q1 and Q3). Whiskers are furthest points that are not outliers (> 1.5 times the interquartile range). Outliers are depicted as open circles (only LFA 33W has outlier in above plot).*

9. CANDIDATE REFERENCE POINTS

9.1. INTRODUCTION AND BACKGROUND – PRECAUTIONARY APPROACH (PA)

A general fishery decision-making framework for implementing a harvest strategy that incorporates the Precautionary Approach (PA) for Canadian fisheries is described in a document on the Fisheries and Oceans Canada website[1].

The following description of DFO's PA approach, and the current approach to PA for Lobster fisheries in LFAs 27-38 is taken from the draft Integrated Fisheries Management Plan (IFMP) for LFAs 27-38. The PA description is based on the above document.

The precautionary approach (PA) is a decision making process with rules which identify triggers and responses during periods of changing stock health. Health of the stock is based on abundance and responses would normally reduce effort on the stock during periods of decreasing abundance or allow increased effort during periods of increased abundance.

In general, the PA in fisheries management is about being cautious when scientific knowledge is uncertain, and not using the absence of adequate scientific information as a reason to postpone action or failure to take action to avoid serious harm to fish stocks or their ecosystem. This approach is widely accepted as an essential part of sustainable fisheries management.

Applying the PA to fisheries management decisions entails establishing a harvest strategy that:

- identifies three stock status zones – healthy, cautious, and critical – according to upper stock and limit reference points (Fig. 9.1);
- sets the removal rate at which fish may be harvested within each stock status zone;
- adjusts the removal rate according to fish stock status variations (i.e., spawning stock biomass or another index/metric relevant to population productivity), based on pre-agreed decision rules

Pre-agreed, risk-based actions will be designed to guide management decisions on harvest rates under various stock status conditions. In the healthy zone, the fish stock status is good, and fisheries management decisions and harvest strategies are designed to maintain fish stocks within this zone. In the cautious zone, decisions and strategies promote stock rebuilding to the healthy zone. In the critical zone, stock growth is promoted and removals are kept to the lowest possible level.

1 A fishery decision-making framework incorporating the Precautionary Approach. (http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/precaution-eng.htm).

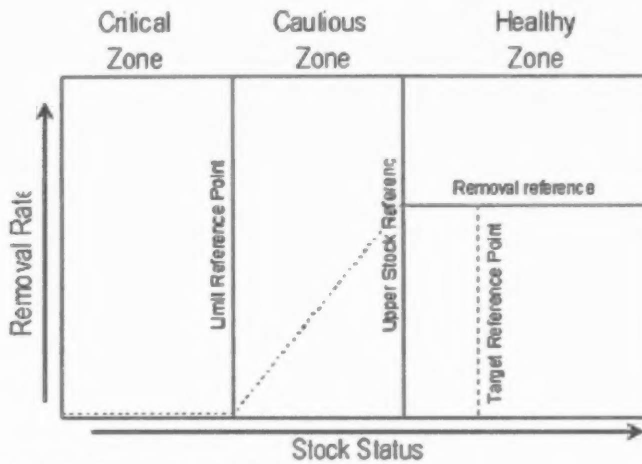


Figure 9.1 – Schematic of the Precautionary Approach

Reference points are based on the productivity objectives of the fishery and can include biological, social and economic factors. Development of quantitative reference points requires data on the stock status and is often expressed as biomass, spawning biomass or abundance. There are no estimates of biomass for lobsters in the Maritimes region so proxies must be developed that will allow for the tracking of changes in stock status even though the absolute biomass estimates remains unknown.

DFO Science is currently reviewing potential proxies for lobsters and determining levels that would represent the Upper Stock Reference point, the Limit Reference Point, and the Target Reference Point. Stock levels above the Upper Stock Reference Point are deemed to be in the "Healthy Zone". If the stock level falls below the Upper Stock Reference Point, the stock has entered the "Cautious zone" and harvest rate begins to be reduced. If the stock level falls below the Limit Reference Point, the stock has entered the "Critical Zone" and management must take serious measures to ensure stock rebuilding.

The Removal Reference Point represents the maximum removal rate, often expressed as Fishing mortality (F) or exploitation rates. Exploitation rate is the ratio of all human removals to total exploitable stock size.

The two FRCC reviews (1995 and 2007) both concluded that in most inshore LFAs exploitation rates were too high. Recent assessments have also identified that in most LFAs exploitation rates were high though the lobster populations themselves had benefited from an extended period of higher than average recruitment and were thus not in immediate danger. However reduced exploitation rates were recommended. Removal reference points will be developed based on historical exploitation levels and output from growth and reproduction models.

The Target Reference Point is a stock level that may be greater than or equal to the Upper Reference Point for the fishery and is a level for the fishery that is considered to be desirable and at which mañagement action should aim. This may take into greater account social and economic aspects of the particular LFA(s).

Currently there are no direct indicators of abundance available for the lobster fishery and more work is needed to develop more biologically based levels. The only long-term information available for all Maritimes region based LFAs is total landings. It is recognized that landings are not a very

sensitive indicator of biomass given the influence of changes in effort, efficiency and catchability. However, until there can be peer reviewed input on the potential use of other indicators this is the only available proxy for abundance that has a significant time series (> 20 years).

Using the proxy of landings as the starting point some candidate interim thresholds for lobster fisheries have been developed based on landings (Tables 9.1). These candidate interim thresholds are informed by what has been adopted in the US lobster fishery and the document "A fishery decision-making framework incorporating the Precautionary Approach".

Currently landings in all LFAs are in the candidate healthy zone (80% of the median landings) (Table 9.2). Most LFAs are also above the median landings for 1985-2004. The exception is LFA 27, which is at the median level but is still 24% higher than the candidate upper reference point.

Table 9.1 *– Initial PA Reference Points based on Total Landings*

Target Reference Point	Undefined for now. It is expected that median landings will only be used for a short period of time until an improved indicator is developed.
Upper Reference Point	**Candidate**: 80% of Median landings 1985-2004
Limit Reference Point	**Candidate**: 40% of median landings
Removal Reference Point	Exploitation rate in assessment (90th percentile for period examined in last available assessment) (essentially a cap while details of requirements reviewed)

1) The target removal reference point will be set at the 90th percentile of exploitation rate estimates for a period identified during the next RAP review process.
2) DFO will begin to work with industry to agree on potential measures to take if the upper stock reference level is reached. All agreed upon potential measures will be assessed for effectiveness through the RAP process.
3) If landing levels decrease to the median landing values, DFO Science Branch will evaluate the cause of the reduction or identify sampling/surveys needed to identify the cause.
4) If landing levels reach 80% of the median landing levels the upper stock reference point will be reached and measures will be taken to reduce the removal rate. These actions may vary depending on the specific conditions of the day but will be based on the measures assessed through the RAP process. Actions will be established in consultation with industry. Reductions in landings caused by changes in the market/economic conditions will be excluded from this PA framework.
5) A lower limit reference point will be tentatively set at 40% of the median landing values.
6) When actions taken allow the state of the stock to recover above a reference point increases in the removal rate can be discussed with industry.
7) A DFO Working Group will be established to refine the precautionary approach. Research will be conducted to develop a better indicator of abundance to be used in the precautionary approach.
8) Changes to this precautionary approach will be made as better information (e.g. better proxies for abundance) becomes available after consultation with all parties. Alternatives may include multi-indicator approaches that establish thresholds for a variety of indicators and reduce the sensitivity of the PA approach to changes in any one indicator or that may not be reflective of changes in stock status.

Table 9.2 – Lobster Landings for LFAs 27-33. Shown are landings for 2009 (2008/09 for LFA 33) together with candidate reference levels.

	LFA33				
2008/2009	3478				
Median 1985-2004	2071				
80%	1,656				
40%	828				
Lowest 1970-2008	213				
Eastern Nova Scotia Landing Values					
	LFA32	**LFA31**	**LFA30**	**LFA27**	**LFA28-29**
2009	776	2171	462	2130	1036
Median 1985-2004	287	301	88	1996	110
80%	229	241	70	1,596	88
40%	115	120	35	798	44
Lowest 1970-2008	49	41	13	547	20

9.2. CONTEXT FOR REFERENCE POINTS – TRENDS IN MULTIPLE INDICATORS

It is recognized that while reference points need to be based on a few key indicators, other indicators should continue to be maintained to capture other types of information that may aid in interpreting changes in key indicators. As such we propose to display trends in other indicators using a format similar to that used for landings (Tables 4.2, 4.3). Indicators that would be displayed here would include landings, fishing effort (numbers of trap hauls) and measures of lobster size. Other indicators including socio-economic indicators could also be added in the future.

9.3. KEY INDICATORS AND POTENTIAL REFERENCE POINTS (RP)

As is indicated above, landings are assumed to relate to abundance, but there are many other factors that affect landings. As such additional indicators of abundance are needed to develop reference points (RP). Australian and New Zealand lobster fisheries have based RP on commercial catch rate, egg production or breeding stock biomass and on pre-recruit indices (Pezzack in DFO, 2010; Miller and Breen 2010). The RP values are often based on a period when the fishery was favourable. In the U.S., stock RP for the lobster fishery from Maine to southern New England have recently been accepted (ASMFC, 2010). They are based on (i) the trend in lobster abundance from a population model, and (ii) the trend in abundance of settled lobsters from a settlement survey (Wilson in DFO 2010).

The U.S. has a significant advantage in assessing lobster stock status since they have two types of fishery-independent surveys in place. One is based on a trawl survey, the other on a trap survey. Until such surveys are in place for Canadian lobster fisheries, there will be more uncertainty with regard to stock status.

Target Reference Points - Based on historical performance as measured by landings, most lobster fisheries are currently well above trend-based Upper Stock RP and definitely a long way from any limit RP. Target RP based on higher yield (biological, economic and social) should be considered but must be developed by industry with DFO in a secondary role. See Miller (2003) and Miller and Breen (2010) for more on target RP.

Options for Reference Points for Next Assessment Cycle - Given the above context we provide some options for implementing RP for the next 4-5 years in LFAs 27-33. In all cases we recommend that the current value of the indicator for comparison with the RP be based on a mean of the last 2-3 years. Option 1 and 2 are not mutually exclusive.

1. Landings as indicator of commercial abundance – maintain until at least next assessment

Example: LFA 33
LRP: 40% of median 1985-2004: 828 mt
URP: 80% of median = 1656 mt

Example: LFA 27
LRP: 40% of median 1985-2004: 798 mt
URP: 80% of median = 1596 mt

Rationale and uncertainty - As discussed in the IFMP, the landings data are the longest time series and there is general agreement that landings are correlated with abundance. There are at least 3 issues related to the use of landings for RPs:

(i) Landings are affected by a range of other factors and are not suitable in the long term for this important fishery. These should be regarded as a coarse indicator of abundance during a transition to indicators that are less sensitive to factors other than abundance.

(ii) Changes in productivity and the period to choose to develop a landings-based RP. Landings have fluctuated substantially over the historical time period. For the purposes of RPs the period 1985-2004 was chosen because current effort levels are likely more similar to this period than pre-1985, and because it includes the period of relatively high landings for most LFAs.

(iii) Level to choose is somewhat arbitrary. 80% of the median landings is suggested above. In the U.S. management action can be triggered if the abundance level is at the median. Some other fisheries use the lowest value of the indicator from which the fishery then recovered. Given uncertainty in historical landings, and given that effort is now higher than 30 years ago, this option does not seem precautionary.

2. Catch rate based indicators for Abundance (commercial sizes) and Production (Prerecruits and spawners)

Rationale and uncertainty - Prerecruit abundance, commercial abundance and measures of spawning stock are all important measures of the health of lobster stocks and thus should be considered in determining RP in lobster. Therefore we recommend that there be RP's for each of the above.

Catch rates are thought to be more closely related to abundance than landings but are also affected by factors other than abundance. Developing RP from CPUE time series shares some of the problems with using landings: changes in productivity and in the selection of the level to use for the RP.

Currently catch rate data from the FSRS traps appear to be the best available data to provide indicators and define RPs for prerecruits and spawners in LFAs 27-33. While promising, the CPUE from the mandatory logs is a short time series, and will still be susceptible to variation in trap type and changes in fishing strategy.

The current value of the indicator should be based on the mean of the most recent 2-3 years.

Potential Reference Points based on CPUE

Abundance of legal Sizes

Recommended indicator: CPUE in FSRS traps (no. per trap haul)
URP: mean FSRS CPUE in 2001-2003.
LRP: 50% of above

Rationale for RPs: The proposed URP is based on the period of lowest FSRS CPUE for the available years, 1999-2009. The mean landings for 2001-2003 were 1550 mt. The LRP is arbitrarily set at 50% of the URP analogous to the landings based RPs (LRP is 50% of the URP). NOTE: *these RPs are based on number rather than weight. As such they may be triggered earlier than the landings based URP because compared to the pre-2002, weight per trap haul now is now greater for the same no. per trap haul because of the increased minimum legal size.*

Abundance of Pre-recruits

Recommended indicator: FSRS CPUE (no. prerecruits per trap haul)
URP: FSRS CPUE mean 2002-2004
LRP: 50% of above

Rationale: The URP is based on the period just after the increase in MLS to 76 mm CL. It represents the low period for the FSRS prerecruit CPUE from 1999-2009. The LRP is arbitrarily set at 50% of the URP analogous to the landings based LRP being set at 50% of the landings-based URP.

Abundance of spawners

Recommended indicator: FSRS CPUE (no. ovigerous fem per trap haul)
URP: FSRS mean CPUE from years 1999-2001
LRP: 50% of above

Rationale: The URP is based on the period at the beginning of the time series when the ovigerous CPUE was lowest. At this point some minimum legal size increases were in place. The LRP is again arbitrarily set. If the ovigerous female CPUE drops to 50% of the level in 1999-2001 serious harm is possible given that a lot more females can now reproduce before becoming harvestable.

9.4. LIMIT REMOVAL RATES

When confidence intervals are considered, exploitation rates have not trended consistently over the period 1999-2009. For LFA 27 only, where extended estimates have been made, current exploitation rates are below that prior to 2007 because of the increased minimum legal size (and the consequent reduction in the size of the harvestable population). We suggest the following with the understanding that the current estimate of the indicator is the mean of the last 3 years.

LFA 27
Proposed limit removal rate – Current value for CCIR extended exploitation rate point estimates should not exceed the mean of the point estimates for the standard exploitation rate 2007-2009.

LFAs 29-32; LFA 33
Current estimate should not exceed the 90th percentile of the period 2002-09.

9.5. POTENTIAL APPLICATION OF LANDINGS AND CATCH RATE RPs

Multiple RPs could be used in the following way. Note that the current value of any indicator would be the mean of the last 2-3 years.

Scenario A – No action
Landings > 80% of median AND commercial CPUE > xx
AND prerecruit CPUE > XX AND spawner index > XX

Scenario B – Triggers assessment of key indicators [possibly via a Science Response] to be completed within 9 months of the end of the fishing season
Any one of Landings, commercial CPUE, prerecruit CPUE or spawner index < USR

Scenario C – Triggers above plus agreed upon reduction in F
Landings < 80% of median AND any one of prerecruit CPUE < XX OR spawner index < XX

Scenario D – Triggers above plus greater reduction in F
Landings < 80% of median AND any two of prerecruit CPUE < XX OR spawner index < XX

9.6. FURTHER DEVELOPMENT OF REFERENCE POINTS

The application of RPs to the lobster fishery in Canada are definitely a work in progress. To improve and develop alternate RPs, the following steps are recommended:

- Seek opportunities to begin fishery independent surveys
- Develop time series from mandatory fishing logs for comparison
- Encourage development of Target RP
- Examine FSRS data from LFA 33 commercial traps
- Further development of egg index e.g. by using size structure from catch and measure of abundance to estimate annual egg index
- Account for first-time vs. multiple spawners
- Monitor size at maturity as this is critical to any egg index calculation
- Explore relationship between effort and CCIR exploitation
- Explore temperature effect on CPUE model
- Explore U.S. population model for another approach to estimating abundance and exploitation rates

9.7. SUMMMARY

The application of the Reference Points (RPs) to lobster fisheries in LFAs 27-33 is discussed in the context of Canada's precautionary approach and the current IFMP for LFAs 27-38. Options for reference point development are provided. The candidate RP in the most recent IFMP for LFAs 27-38 are based on landings from 1984-2004. For example the candidate upper reference point is 80% of Median landings 1985-2004. Landings are assumed to relate to abundance, but there are many other factors that affect landings. As such additional indicators of abundance are needed to develop RP. Other lobster fisheries have based RP on commercial catch rate, egg production or breeding stock biomass and on pre-recruit indices. For LFAs 27-33 moving beyond using landings to develop RPs will likely be incremental. An abundance index for pre-recruits and commercial sizes based on FSRS catch rates is feasible for some assessment units. The development of

indices of reproduction will require additional analyses and potentially new sources of data. Recommendations for further development of RPs are provided.

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APPENDICES

Appendix 1 – Lobster Catch and Settlement Report

Fisheries and Oceans Canada / Pêches et Océans Canada

CONFIDENTIAL
CONFIDENTIEL

For DFO use only / À l'usage du MPO

000760
SERIAL NUMBER / NUMÉRO DE SERIE

LFA 27-38 Lobster Catch and Settlement Report for Month / Rapport de prises et de transactions concernant la pêche du homard dans les ZPH 27 à 38 pour le mois de ____________ Year/Annee ________ LFA/ZPH ________

Vessel Registration No. / N° d'immatriculation du bateau ____________ *No. of Crew Including Captain / N° de membres d'équipage, y compris le capitaine* ____________ *Lobster Licence Control No. / N° du permis de pêche du homard* ____________

Vessel Name / Nom du bateau ____________ *Name of License Holder/Operator / Nom du titulaire de permis* ____________

Day of Month / Jour	Estimated Lobster Landings / Débarquements de homard estimés — First Grid / Premier secteur de quadrillage			Second Grid / Deuxième secteur de quadrillage			Third Grid / Troisième secteur de quadrillage			[illegible]		[illegible]	[illegible]	Weighout Information / Données de pesage — NO SALES IN MONTH / PAS DE VENTE DANS LE MOIS ☐			
	Grid # on Map / N° de quadrillage sur la carte	Pounds Landed / Livres débarquées	Trap Hauls / Casiers levés	Grid # on Map / N° de quadrillage sur la carte	Pounds Landed / Livres débarquées	Trap Hauls / Casiers levés	Grid # on Map / N° de quadrillage sur la carte	Pounds Landed / Livres débarquées	Trap Hauls / Casiers levés	[illegible]	[illegible]			Date Sold / Date de la vente	Buyer / Acheteur	Market / Homard de marche	Price / Prix
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[illegible]

Signature of License Holder / Operator
Signature du titulaire de permis ____________

White - DMC Copy / Exemplaire blanc - EVQ
Yellow - Fisher Copy / Exemplaire jaune - Pêcheur

Appendix 2 – Lobster/Crab Sea Sampling Protocol

(last modified June 14, 2002)

A) General Objective:

To obtain fisheries information on lobster and crab population size structure, catch and effort through at-sea sampling of commercial and research trap catches in inshore, midshore and offshore areas (LFA's 34-41).

B) Pre-Trip Preparation:

- Familiarize yourself with the safety procedures as indicated in the document "Safety Guidelines for At-Sea Sampling aboard Vessel of Opportunity" and obtain names of recommended captain's from the Vessel of Opportunity recommendation list, previously compile by qualified DFO personal.

- Check weather report for sampling location.

- Initiate contact with captains on VOP recommendation list, during the evening prior to the sampling day. If this is your first contact with the captain, introduce yourself as a DFO Science technician or biologist and explain to him what type of information you are collecting. If unsure on weather conditions ask the captain for an opinion on the next day's weather in the local area.

- After agreeing on a departure time with the fishermen, plan to arrive at the wharf at least 15 to 30 minutes before the stated departure time. This extra time can be used to get the sampling gear ready, find the boat you are going on, help fishermen loading bait or other gear, etc. The extra time will also help you with fishermen who sometimes change departure time without notice (because of tides, etc.) and leave earlier without you.

C) Onboard Procedures:

Inform the captain as to what type of sampling is required and ask him for an area on the boat that would be safe to work in with minimum exposure to the weather and minimum disruption to the fishers.

D) Confidentiality of Information:

Biological information recorded while on commercial vessels or facts you are told on commercial fishing activity, are considered confidential and should not be discussed with other fishermen or with DFO samplers when members of the public are present (e.g. on wharf).

E) Biological Sampling Objectives:

- Measure all lobsters/crab within each individual trap including shorts and berried females.

- The standard measurement of the carapace length for lobsters (distance between the eye socket and the base of the carapace) and carapace width for crab (the widest part of the carapace) is taken with vernier callipers to the nearest millimetre.

-Before sampling, verify with DFO sea sampling coordinator, what is the current minimum legal size for lobsters/crabs in the fishing area you are sampling. For lobsters/crab, when measurement is close to the minimum legal size (within a millimetre) use the fishermen's measure to verify if of legal size. If not sure either ask fishermen or throw overboard. For lobsters/crab rounding should be to the nearest mm.

-Identify the sex of each lobster/crab:

1 = male
2 = female
3 = berried female

-Record shell hardness: Make a quick assessment of shell hardness, code 2, 5 or 7 are typically encountered:

1 = soft jelly texture
2 & 3 = shell hardening but would break if pressure was exerted
4, 5 and 6 = hard shell (can't break claw or shell when pressure is exerted)
7 = ready to molt and shell started to split along lateral line

-Record egg stage if berried:

1 = new eggs (dark green eggs with no eye spot)
2 = old eggs (green or brown eggs with black dots or eye spots visible)
3 = partial hatch (some eggs are hatching, usually a light bluish color)

-Record location (Latitude and Longitude)
by using the boats instrument or hand held GPS at the beginning and end of every string of traps or more often if possible. The preferred positional data is LAT. and LONG. in decimal minutes (e.g. 4243.79 6525.39)

-Record depth in fathoms (as least once for each string):

-Record the numbers of soak days since the last time the traps were hauled.

-Record V-notch condition for lobsters:

V-shaped notch, are supposed to be located in the right flipper next to the middle flipper of female lobsters. The right flipper is determined when the underside of the lobster is down and its tail is toward the person making the determination.

1 = V-notched by fisherman during current trip
2 = new V-notch (flesh or scar tissue visible)
3 = old V-notch (molted, shell material but no setal hairs
4 = old V-notch with setal hairs
5 = Mutilated or missing flipper

-Record cull condition for lobsters:

1 = one claw
2 = zero claws
3 = regenerating claw (soft claw bud visible)

F) Trap sampling:

The objective is to sample every trap during a sea trip. However, in the event that the volume of catch is too great to perform total trap sampling (e.g. at the beginning of the lobster season, or when sampling trawls in the offshore, etc.) sub-sampling is permitted. It is up to your own discretion as to how you are going to sub-sample. If you decide to sample every second trap or every third trap, etc., the method of sub-sampling should be done the same way throughout the whole sample or within each string, and recorded in the comments.

G) Data Verification:

All sea sampling forms should be checked for inconsistent or unclear handwriting/numerals in data fields. In extreme conditions original data may need to be copied onto clean forms after sampling trip. After verification the data sheets should be signed and dated by sampler and submitted for data entry into sections' databases within one week of data collection.

Appendix 3 – SARA Lobster Fishery Sampling

A) General Objective:
The primary objective is to obtain fisheries information about bycatch of other species (primarily species at risk and fish) in the commercial lobster trap fishery in inshore, midshore and offshore areas (LFA's 27-41). In addition fisheries information will be collected on lobster and crab for use in the analysis of population size structure, catch and effort.

B) Focus:
These will be regular observer trips with a focus on sampling all by-catch as a priority over the directed species (lobster and crab).

C) Deployments:
5% observer coverage, within budget constraints.

D) Biological Sampling Objectives:
Collect length frequency, weights and numbers for the following SARA / COSEWIC species from all traps in a string:

- Cusk
- Cod
- Skates
- Wolfish
- Salmon
- Pollock
- Ocean pout
- Shad
- American eel
- Striped bass
- Flounders
- Monkfish
- Haddock

Whenever possible completely sample every trap for SARA/COSEWIC species, lobsters and other species as per the "**Total Trap Sampling**" protocol below. If lobster and non-SARA/COSEWIC species data cannot be collected from a trap because of time constraints, make note of this on the sampling data sheet. If there are high catch rates and it is not possible to follow the "Total Trap Sampling" protocol for every trap, do the next trap available when sampling is completed on the current trap. Make sure empty traps are recorded. Traps which are hauled empty should be included on the sample form with a comment "empty".

Ensure that all traps that are selected for "Total Trap Sampling" are sampled completely for all species.

Total Trap Sampling:
First priority:

1. Collect catch weight for lobster and all bycatch species as per observer guidelines.
2. Collect length frequency, weights and numbers for the following SARA / COSEWIC species:
   - Cusk
   - Cod
   - Skates
   - Wolfish
   - Salmon
   - Pollock
   - Ocean pout
   - Shad
   - American eel
   - Striped bass
   - Flounders
   - Monkfish
   - Haddock
3. Measure and sample all lobsters, Jonah, rock and red crabs as per LFA 41 and 34 protocols.

Second Priority:

- Count all other fish
- Count invertebrates (sea stars, whelks, hermit crabs, etc.). If there are a large number of small invertebrates, estimate the number rather than counting each one individually.

Appendix 4 – SQL Query Examples

Appendix 4 .1 – Example of LFA 33 query for the 2008-2009 season, fall period, average CPUE

```
--queries shows the removals of the zero weights and trap hauls, but redundant due to
specifying a range value later in query
--fall
select area, area_b, area_c, round(avg(all_cpue),3) avg_cpue, count(all_cpue) from (
select a.*, b.area area_c from (
select a.*, b.area area_b from (
select a.sum_doc_id, a.sd_log_id, a.vr_number, a.vessel_name, a.submitter_name,
a.licence_id, a.lfa, a.date_fished,
a.weight_lbs, a.weight_lbs_b, a.weight_lbs_c, a.num_of_traps th, a.num_of_traps_b
thb, a.num_of_traps_c thc,
a.grid_num, a.grid_num_b, a.grid_num_c, a.community_code, b.area,
round(round(nvl(a.weight_lbs/2.2046,0)+nvl(a.weight_lbs_b/2.2046,0)+nvl(a.weight_lbs_
c/2.2046,0),4)/
round(nvl(a.num_of_traps,0)+nvl(a.num_of_traps_b,0)+nvl(a.num_of_traps_c,0),0),3)
all_cpue
from LOBLOGSD a, lfa33_centgrid b --MARFIS view of lobster log data and table of LFA
33 grids and subunits
where a.grid_num = b.grid_num(+) -- allocates grid_a to lfa 33 subunit
and a.LFA = '33' --lobster fishing area 33
and a.DATE_FISHED between '2008-11-25' and '2008-12-31'--fall period for 2008-2009
season
and a.licence_id not in (111226,110272,109818,112213) --removal of licences with less
than 5 days fished in the season
and nvl(a.weight_lbs,0)+nvl(a.weight_lbs_b,0)+nvl(a.weight_lbs_c,0) !=0 --sum of all
weight can't equal zero
and nvl(a.num_of_traps,0)+nvl(a.num_of_traps_b,0)+nvl(a.num_of_traps_c,0) !=0 --sum
of all trap hauls can't equal zero
and nvl(a.grid_num,0)+nvl(a.grid_num_b,0)+nvl(a.grid_num_c,0)+nvl(a.community_code,0)
!=0 -- a,b or c grid or community_code cannot be null or zero
and nvl(a.weight_lbs,0)+nvl(a.weight_lbs_b,0)+nvl(a.weight_lbs_c,0) >=10 --sum of all
weight must be greater than or equal to 10
and nvl(a.num_of_traps,0)+nvl(a.num_of_traps_b,0)+nvl(a.num_of_traps_c,0) between 10
and 550 --sum of all trap hauls is between 10 and the trap limit plus 10%
)a, lfa33_centgrid b
where a.grid_num_b = b.grid_num(+) --allocates grid_b to lfa 33 subunit
)a, lfa33_centgrid b
where a.grid_num_c = b.grid_num(+) -- allocates grid_c to lfa 33 subunit
order by a.sd_log_id
)
group by area, area_b, area_c
order by area
```

Appendix 4.2 – Example of LFA 32 query for the 2010 season, average CPUE

```
--LFA 32 2010
select round(avg(all_cpue),3) avg_cpue, count(all_cpue) from (
select a.sum_doc_id, a.sd_log_id, a.vr_number, a.vessel_name, a.submitter_name,
a.licence_id, a.lfa, a.date_fished,
a.weight_lbs, a.weight_lbs_b, a.weight_lbs_c, a.num_of_traps th, a.num_of_traps_b thb,
a.num_of_traps_c thc,
a.grid_num, a.grid_num_b, a.grid_num_c, a.community_code,
round(round(nvl(a.weight_lbs/2.2046,0)+nvl(a.weight_lbs_b/2.2046,0)+nvl(a.weight_lbs_c/2.
2046,0),4)/
round(nvl(a.num_of_traps,0)+nvl(a.num_of_traps_b,0)+nvl(a.num_of_traps_c,0),0),3)
all_cpue
from LOBLOGSD a --MARFIS view of lobster log data
where a.LFA = '32' --lobster fishing area 32
and a.DATE_FISHED between '2010-04-20' and '2010-06-20' --lfa 32 fishing season for 2010
and nvl(a.weight_lbs,0)+nvl(a.weight_lbs_b,0)+nvl(a.weight_lbs_c,0) >=10 --sum of all
weight must be greater than or equal to 10
and nvl(a.num_of_traps,0)+nvl(a.num_of_traps_b,0)+nvl(a.num_of_traps_c,0) between 10 and
550 --sum of all trap hauls is between 10 and the trap limit plus 10%
)
```

Appendix 4.3 – Example of LFA 27 query for the 2010 season, average CPUE

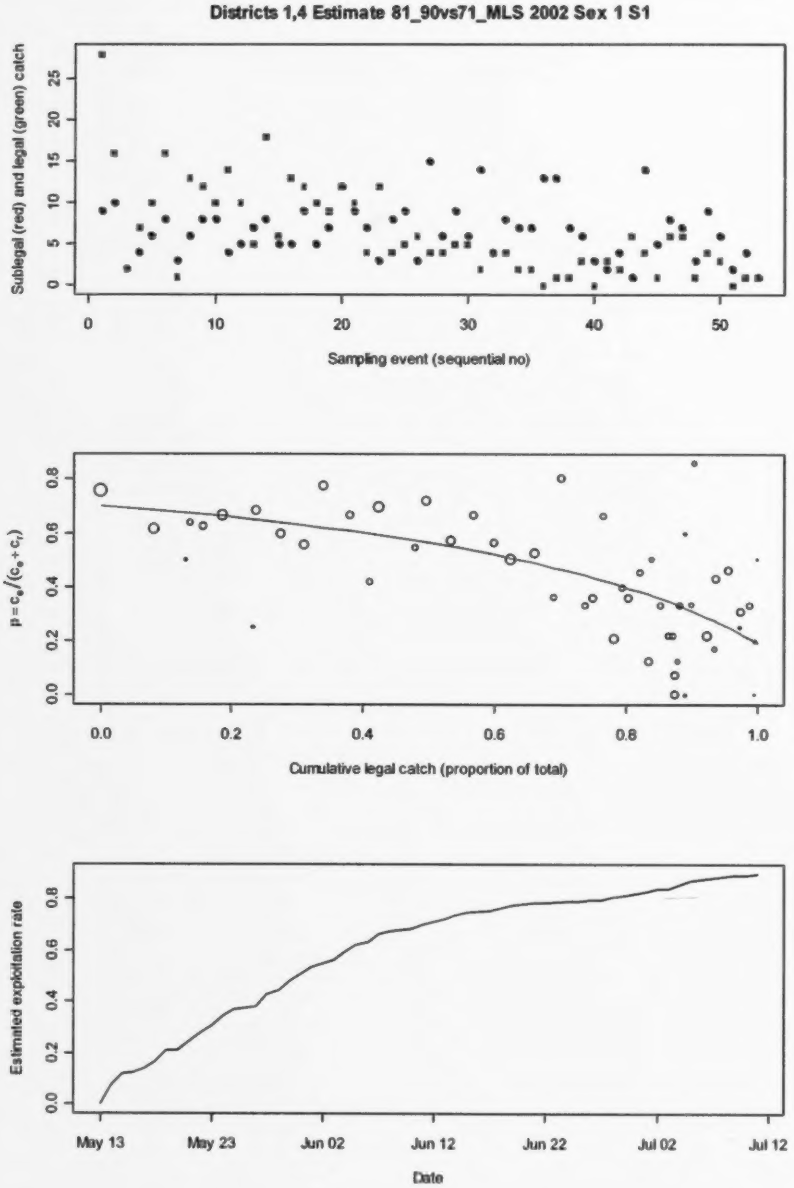
```
select area, area_b, area_c, round(avg(all_cpue),3) avg_cpue, count(all_cpue) from (
select a.*, b.area area_c from (
select a.*, b.area area_b from (
select a.sum_doc_id, a.sd_log_id, a.vr_number, a.vessel_name, a.submitter_name,
a.licence_id, a.lfa, a.date_fished,
a.weight_lbs, a.weight_lbs_b, a.weight_lbs_c, a.num_of_traps th, a.num_of_traps_b thb,
a.num_of_traps_c thc,
a.grid_num, a.grid_num_b, a.grid_num_c, a.community_code, b.area,
round(round(nvl(a.weight_lbs/2.2046,0)+nvl(a.weight_lbs_b/2.2046,0)+nvl(a.weight_lbs_c/2.
2046,0),4)/
round(nvl(a.num_of_traps,0)+nvl(a.num_of_traps_b,0)+nvl(a.num_of_traps_c,0),0),3)
all_cpue
from LOBLOGSD a, lfa27_32_centgrid b --MARFIS view of lobster log data and table of LFA
27-32 grids and sub units
where a.grid_num = b.grid_num(+) --allocates grid_a to lfa 27 subunit
and a.LFA = '27' --lobster fishing area 27
and a.DATE_FISHED BETWEEN '2010-05-10' AND '2010-07-15' --2010 season
and a.licence_id not in (004744) --removal of licences with less than 5 days fished in
the season
and nvl(a.grid_num,0)+nvl(a.grid_num_b,0)+nvl(a.grid_num_c,0)+nvl(a.community_code,0) !=0
-- a,b or c grid or community_code cannot be null or zero
and nvl(a.weight_lbs,0)+nvl(a.weight_lbs_b,0)+nvl(a.weight_lbs_c,0) >=10 --sum of all
weight must be greater than or equal to 10

and nvl(a.num_of_traps,0)+nvl(a.num_of_traps_b,0)+nvl(a.num_of_traps_c,0) between 10 and
605 --sum of all trap hauls is between 10 and the trap limit plus 10%
)a, lfa27_32_centgrid b
where a.grid_num_b = b.grid_num(+)  allocates grid_b to lfa 27 subunit
)a, lfa27_32_centgrid b
where a.grid_num_c = b.grid_num(+)--allocates grid_c to lfa 27 subunit
order by a.sd_log_id
)
group by area, area_b, area_c
order by area
```

Appendix 5 – Example of CCIR within-season data and plots

Appendix 5.1 – Details of annual exploitation rate estimates for one estimate type in LFA 27 in 2002 and 2008 (Type 2, exploited size class=81-90 mm CL and reference size class=71 mm CL to MLS. Shown are estimates for males and females in 2 subunits.

Appendix Table 5.1.1 – *Year = 2002, northern subunit (SD 1,4), Males. Shown is date and number of lobsters in each class. Ref = Reference class, Exp= exploited class.*

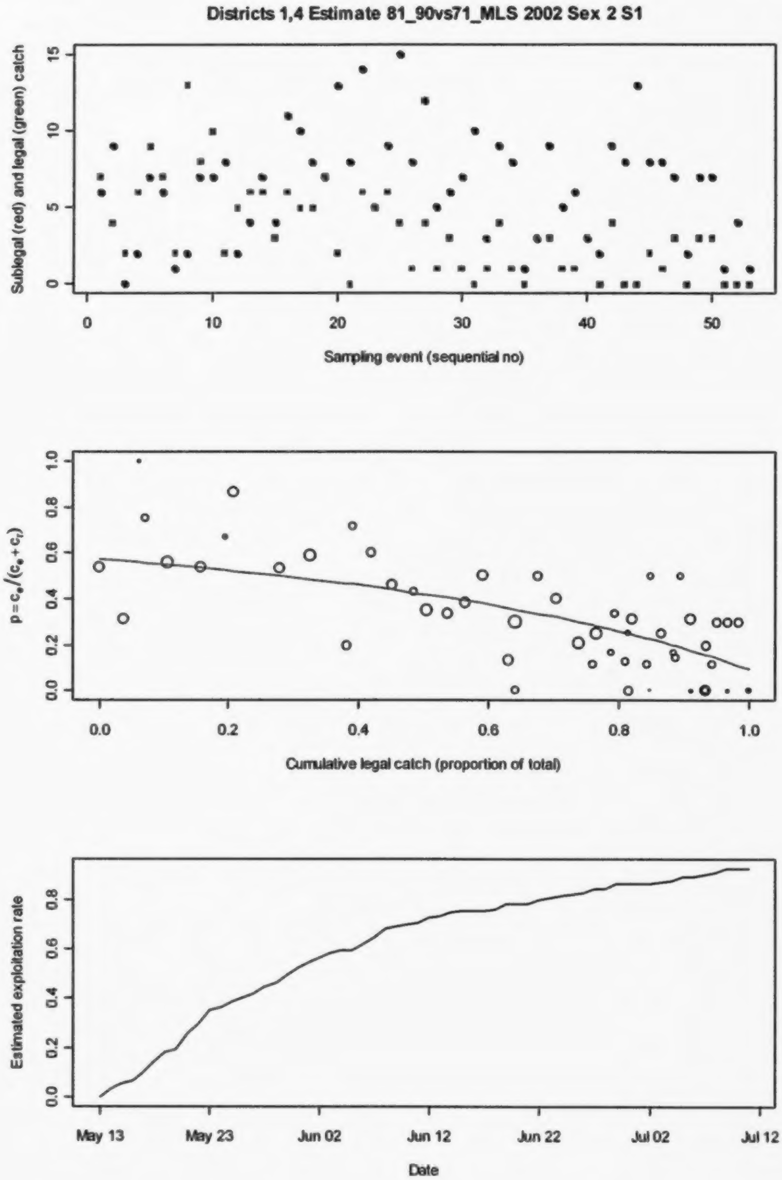
"DateField"	"Ref"	"Exp"
2002-05-13	9	28
2002-05-14	10	16
2002-05-15	2	2
2002-05-16	4	7
2002-05-17	6	10
2002-05-18	8	16
2002-05-19	3	1
2002-05-20	6	13
2002-05-21	8	12
2002-05-22	8	10
2002-05-23	4	14
2002-05-24	5	10
2002-05-25	7	5
2002-05-27	8	18
2002-05-28	5	6
2002-05-29	5	13
2002-05-30	9	12
2002-05-31	5	10
2002-06-01	7	9
2002-06-03	12	12
2002-06-04	9	10
2002-06-05	7	4
2002-06-06	3	12
2002-06-07	8	4
2002-06-08	9	5
2002-06-10	3	6
2002-06-11	15	4
2002-06-12	6	4
2002-06-13	9	5
2002-06-14	6	5
2002-06-15	14	2
2002-06-17	4	4
2002-06-18	8	4
2002-06-19	7	2
2002-06-20	7	2
2002-06-21	13	0
2002-06-22	13	1
2002-06-24	7	1
2002-06-25	6	3
2002-06-26	3	0
2002-06-27	2	3
2002-06-28	4	2
2002-06-29	1	6
2002-07-01	14	4
2002-07-02	5	1
2002-07-03	8	6
2002-07-04	7	6
2002-07-05	3	1
2002-07-06	9	4
2002-07-08	6	3
2002-07-09	2	0
2002-07-10	4	1
2002-07-11	1	1



***Appendix Fig. 5.1.1** – Plots related to exploitation estimates for 81-90 mm CL males (Sex=1) in northern subunit in 2002. Top panel shows catch of legals and sublegals. Middle plan shows seasonal change in ratio of exploited/(exploited + reference). Size of symbols reflects relative number of total lobsters caught to indicate influence on loss function. Lower panel shows seasonal change in cumulative exploitation rate.*

Appendix Table 5.1.2 *– Year = 2002, northern subunit (SD 1,4), Females. Shown is date and number of lobsters in each class. Ref = Reference class, Exp= exploited class.*

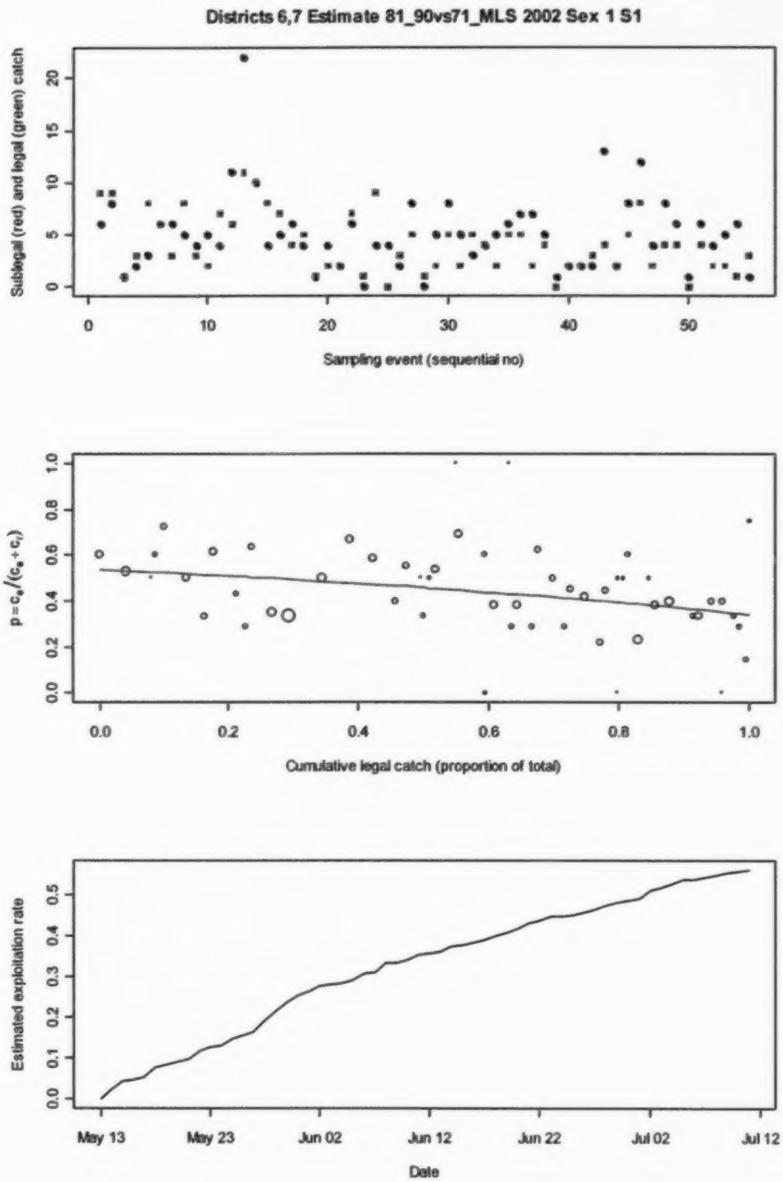
"DateField"	"Ref"	"Exp"
2002-05-13	6	7
2002-05-14	9	4
2002-05-15	0	2
2002-05-16	2	6
2002-05-17	7	9
2002-05-18	6	7
2002-05-19	1	2
2002-05-20	2	13
2002-05-21	7	8
2002-05-22	7	10
2002-05-23	8	2
2002-05-24	2	5
2002-05-25	4	6
2002-05-27	7	6
2002-05-28	4	3
2002-05-29	11	6
2002-05-30	10	5
2002-05-31	8	5
2002-06-01	7	7
2002-06-03	13	2
2002-06-04	8	0
2002-06-05	14	6
2002-06-06	5	5
2002-06-07	9	6
2002-06-08	15	4
2002-06-10	8	1
2002-06-11	12	4
2002-06-12	5	1
2002-06-13	6	3
2002-06-14	7	1
2002-06-15	10	0
2002-06-17	3	1
2002-06-18	9	4
2002-06-19	8	1
2002-06-20	1	0
2002-06-21	3	3
2002-06-22	9	3
2002-06-24	5	1
2002-06-25	6	1
2002-06-26	3	3
2002-06-27	2	0
2002-06-28	9	4
2002-06-29	8	0
2002-07-01	13	0
2002-07-02	8	2
2002-07-03	8	1
2002-07-04	7	3
2002-07-05	2	0
2002-07-06	7	3
2002-07-08	7	3
2002-07-09	1	0
2002-07-10	4	0
2002-07-11	1	0



Appendix Fig. 5.1.2 *– Plots related to exploitation estimates for 81-90 mm CL females (Sex=2) in northern subunit in 2002. Top panel shows catch of legals and sublegals. Middle plan shows seasonal change in ratio of exploited/(exploited + reference). Size of symbols reflects relative number of total lobsters caught to indicate influence on loss function. Lower panel shows seasonal change in cumulative exploitation rate.*

***Appendix Table 5.1.3** – Year = 2002, southern subunit (SD 6,7), Males. Shown is date and number of lobsters in each class. Ref = Reference class, Exp= exploited class.*

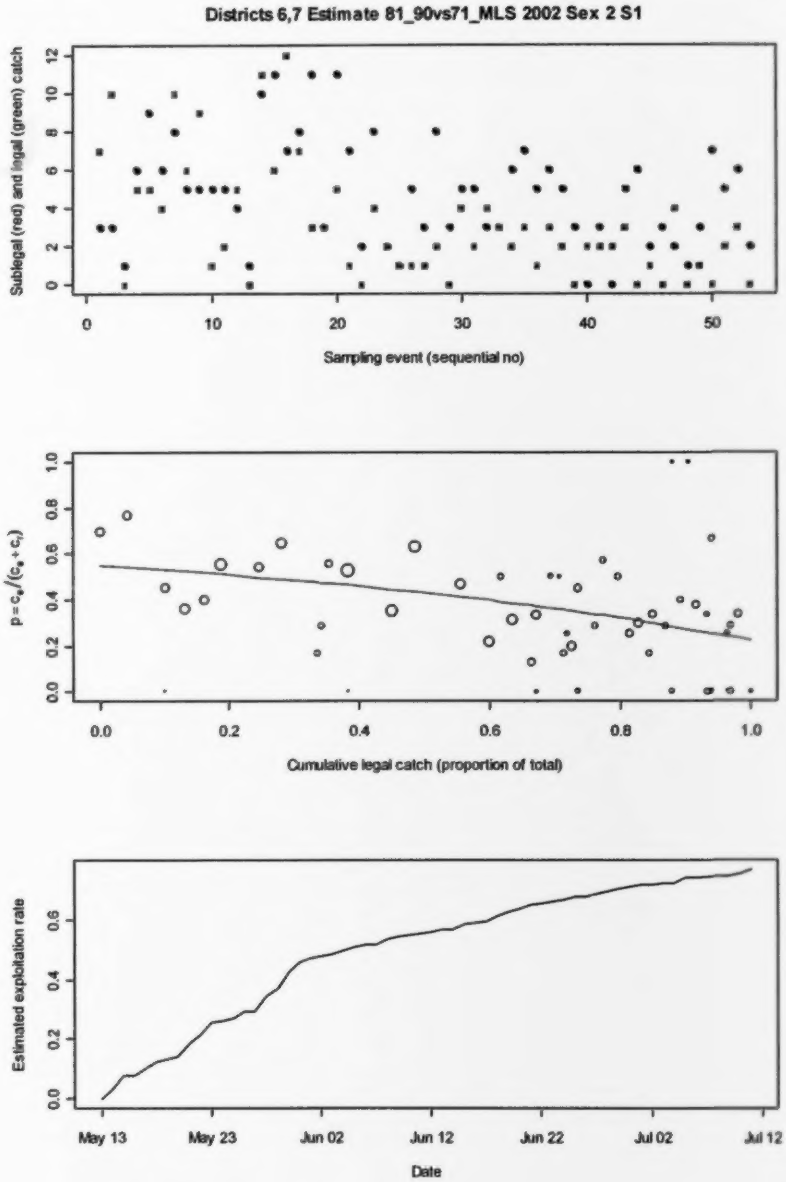
"DateField"	"Ref"	"Exp"
2002-05-13	6	9
2002-05-14	8	9
2002-05-15	1	1
2002-05-16	2	3
2002-05-17	3	8
2002-05-18	6	6
2002-05-20	6	3
2002-05-21	5	8
2002-05-22	4	3
2002-05-23	5	2
2002-05-24	4	7
2002-05-25	11	6
2002-05-27	22	11
2002-05-28	10	10
2002-05-29	4	8
2002-05-30	5	7
2002-05-31	6	4
2002-06-01	4	5
2002-06-02	1	1
2002-06-03	4	2
2002-06-04	2	2
2002-06-05	6	7
2002-06-06	0	1
2002-06-07	4	9
2002-06-08	4	0
2002-06-09	2	3
2002-06-10	8	5
2002-06-11	0	1
2002-06-12	5	2
2002-06-13	8	5
2002-06-14	5	2
2002-06-15	3	5
2002-06-17	4	4
2002-06-18	5	2
2002-06-19	6	5
2002-06-20	7	5
2002-06-21	7	2
2002-06-22	5	4
2002-06-23	1	0
2002-06-24	2	2
2002-06-25	2	2
2002-06-26	2	3
2002-06-27	13	4
2002-06-28	2	2
2002-06-29	8	5
2002-07-01	12	8
2002-07-02	4	2
2002-07-03	8	4
2002-07-04	6	4
2002-07-05	1	0
2002-07-06	6	4
2002-07-08	4	2
2002-07-09	5	2
2002-07-10	6	1
2002-07-11	1	3



Appendix Fig. 5.1.3 *– Plots related to exploitation estimates for 81-90 mm CL males (Sex=1) in southern subunit in 2002. Top panel shows catch of legals and sublegals. Middle plan shows seasonal change in ratio of exploited/(exploited + reference). Size of symbols reflects relative number of total lobsters caught to indicate influence on loss function. Lower panel shows seasonal change in cumulative exploitation rate.*

Appendix Table 5.1.4 *– Year = 2002, southern subunit (SD 6,7), Females. Shown is date and number of lobsters in each class. Ref = Reference class, Exp= exploited class.*

"DateField"	"Ref"	"Exp"
2002-05-13	3	7
2002-05-14	3	10
2002-05-15	1	0
2002-05-16	6	5
2002-05-17	9	5
2002-05-18	6	4
2002-05-20	8	10
2002-05-21	5	6
2002-05-22	5	9
2002-05-23	5	1
2002-05-24	5	2
2002-05-25	4	5
2002-05-26	1	0
2002-05-27	10	11
2002-05-28	11	6
2002-05-29	7	12
2002-05-30	8	7
2002-05-31	11	3
2002-06-01	3	3
2002-06-03	11	5
2002-06-05	7	1
2002-06-06	2	0
2002-06-07	8	4
2002-06-08	2	2
2002-06-09	1	1
2002-06-10	5	1
2002-06-11	3	1
2002-06-12	8	2
2002-06-13	3	0
2002-06-14	5	4
2002-06-15	5	2
2002-06-17	3	4
2002-06-18	3	3
2002-06-19	6	2
2002-06-20	7	3
2002-06-21	5	1
2002-06-22	6	3
2002-06-24	5	2
2002-06-25	3	0
2002-06-26	0	2
2002-06-27	3	2
2002-06-28	0	2
2002-06-29	5	3
2002-07-01	6	0
2002-07-02	2	1
2002-07-03	3	0
2002-07-04	2	4
2002-07-05	1	0
2002-07-06	3	1
2002-07-08	7	0
2002-07-09	5	2
2002-07-10	6	3
2002-07-11	2	0



Appendix Fig. 5.1.4 *– Plots related to exploitation estimates for 81-90 mm CL females (Sex=2) in southern subunit in 2002. Top panel shows catch of legals and sublegals. Middle plan shows seasonal change in ratio of exploited/(exploited + reference). Size of symbols reflects relative number of total lobsters caught to indicate influence on loss function. Lower panel shows seasonal change in cumulative exploitation rate.*